Total Quality Environmental Management (TQEM) Framework Towards Sustainability (UK Novated D&B Principal Contractors)

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ABSTRACT

To reduce the substantial environmental damage of the built environment, contractors have to comply with an increasing number of environmental building regulations. Apart from the purely practical implications of compliance, there is a perception of a gap emerging from not joining up the construction cycle with management-based solutions for performance development, especially in newer areas of interest such as the environment and sustainability. Research has shown that out of the variety of the procurement routes the UK construction industry offers, there has been a continuous increase in the use of novated Design-and-Build (D&B) over the last 15 years. Many clients regard it as providing value for money and the contractors see it as an opportunity to apply their key strengths in management and coordination of design and construction works. The situation of high adoption of D&B, despite its poor quality and environmental performance, motivated this research to develop a management-based solution for performance improvement from the novated D&B principal contractors' perspective.

To date, the bulk of empirical research on environmental management issues has been directed toward quality, strategy, supply chain, and process management. The development of Total Quality Environmental Management (TQEM) may improve environment, quality, sustainability, client's value for money, and at the same time reduce contractors' risks. TQEM has emerged, in the manufacturing sector, from integrating strategic Environmental Management (EM) into the holistic approach of Total Quality Management (TQM). TQEM embodies four key principles: customer identification, continuous improvement, doing the job right the first time and a system approach. The impact of TQEM on construction management, design, performance, and procurement are not always as visible to the end-users as they are to the contractor. To be able to define these elements in a construction project, contractors' perspectives need to be studied with regard to the corporate-level TQEM (cultural and business aspects) and project-level TQEM (construction performance and procurement arrangements).

The aim of this research therefore is to establish the suitability of TQEM for D&B main contractors across the major classification of project types. The triangulation approach in the study combines two levels for investigation; a survey and case studies. There are two main reasons for selecting this approach: 1) the two different methods are used for different purposes as the survey focuses on corporate-level TQEM while the case studies are concerned with the project-level TQEM; and 2). This use of multi-methods enables

triangulation to take place in order to ensure that the data is reliable. For the survey, a primary group of top D&B contractors who are likely to be most affected by the new environmental regulations are included in the sample frame. For the case studies, within the three selected reputable D&B main contractors, secondary groups of top, middle and project level managers' opinions, are investigated.

The findings illustrate the demand for TQEM and suggest extending TQEM processes over the project development stages. The survey results are analyzed to refine a primary TQEM framework which would hopefully be sufficiently general for implementation purposes. Understanding the case studies' informants' professional standing and the significance of their comments is enhanced for ensuring the primary TQEM framework external validity. The framework is developed further through the provision of rich, thick detailed description out of the case studies which allow any other D&B contractor interested in transferability to have a solid framework for comparison. Hence, this research provides the basis for further studies into how TQEM can be enhanced in a way that will provide contractors with sustainable competitive advantages.

The research contribution to knowledge is born from reasoned reflections and principled convictions. A new concept of Const.TQEM and a new framework for performance improvement towards sustainability for novated D&B main contracts are developed by this research. The Const.TQEM framework has a potentially massive impact on the timing and nature of the design, of contractor intervention, recognition, and of the contractual and working relationships of the parties involved in a project. By picturing the interaction between the whole parties involved in a novated D&B project, this new framework overcomes many of the shortcomings of the conventional D&B method of construction procurement, enables greater concurrency in design development and project planning, balances priorities, and generates realistic plans. A combination of originality & credibility increased resonance and usefulness and subsequently value of contribution. This research develops a solution for the gap found in the literature by refining and extending current practices of compliance with the new environmental regulations from the design phase, to the managerial and procurement arrangements picturing the interaction among all the parties involved in a project realisation.

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INTRODUCTION

CHAPTER ONE: INTRODUCTION

1.1 Background of the Research Problem

The Construction Matters Report (2008) highlighted that the UK construction industry is central to both the UK economy and the built environment. The construction industry provided employment for more than 2.8 million people and contributed 8.7% of the UK economy gross value-added (GVA) in 2006. Construction contribution to the built environment is a key to climate change adaptation, mitigation and the long-term objective of making the UK a low-carbon society, because buildings account for around half of greenhouse gas emissions (Construction Matters Report, 2008).

This necessitates, according to World Federation of Engineering Organisations (WFEO, 2002), a focus on the construction industry's extraction and processing of natural resources, designing and building infrastructure, meeting the needs of consumers and distributing energy. In practice, the energy used within buildings accounts for nearly 50% of UK CO2 emissions with a further 10% arising from the production of construction materials. Buildings use almost 70% of the nation's electricity. Each year the UK construction industry uses 6 tonnes of building materials per head of population and waste from materials production and construction amount to 151 million tonnes per annum or 35% of UK total waste (BRE, 2008).

The demand to resolve this environmental impact can not be separated from the construction industry's need to deliver projects successfully in terms of time, cost, and design quality, as both have a major impact on the economy's wider performance (Barrett, 2008b). For the purpose of this study, the construction industry is considered to comprise those companies involved in the physical construction of house building, infrastructure, industrial construction, commercial construction and building materials (Barrett, 2008a). The construction matters report (2008) highlighted a range of problems that the UK construction industry has suffered from. The report indicates a deep concern that the UK construction industry, as a whole, is underachieving for the following reasons:

- It operates on low profit margins. These margins are too low for the industry to sustain development.

- The industry invests too little in capital and research and development. This is causing difficulties in ensuring quality and continuous improvement.

- There is crisis in training. The workforce is insufficiently trained.

- Inappropriate contractual relationships are in place between different parts of the construction supply chain.

- Lack of setting and implementing new targets, strategies, plans and policies in conjunction with government established Strategy for Sustainable Construction.

The first three points stated above match Egan's findings in 1998. Egan recommended, in The Construction Industry Task Force Report, that the construction industry should set itself clear objectives for performance improvement. For the fourth point, it was recommended that the traditional construction procurement and management dimensions of time, quality and cost should be augmented by a fourth dimension – the environment – throughout the construction supply chain (Dainty *et al.*, 2007; Bouchlaghem *et al.*, 2008). Out of the non-traditional procurement routes, (Design-and-Build) D&B strategy was recommended by the Sustainable Procurement Report (2006). This is because D&B route enables clients to have the capability to procure a construction based on whole life value (Sustainable Procurement Report, 2006).

In relation to the fourth point noted above, Simms, in Sustainable Development Strategy for Civil Engineering 2007, recommended developing a management-based approach to achieve sustainable construction objectives. This is because integrating the Sustainable Development Strategy for civil engineering without an accompanying management-based framework is challenging and will not make a positive impact on construction companies' performance in a short time (Simms, in: Sustainable Development Strategy for Civil Engineering, 2007). Consequently, this suggested management-based framework should comprise the following Sustainable Development Strategy list of recommendations for civil engineering organisations: a) improve management-based strategy of impacts and resource, b) improve productivity, including whole life-cycle assessments, c) engage the supply chain at the earliest possible stages of a project to ensure sustainable development principles are embedded, d) promote the business case for sustainable, and e) be accountable for performance with respect to sustainability.

The construction industry continues to face substantial demands for improvement in environmental performance, quality and cost control, and a reduction in contract disputes (Oakland *et al*., 2006). The need to establish a performance improvement framework for the UK construction companies was highlighted by many academic and construction professionals (Green *et al.*, 2008; Bouchlaghem *et al.*, 2008; Dainty *et al.*, 2007). Despite a number of management concepts that have been promoted, many in the industry find the concepts confusing and are sceptical about their usefulness (Kibert, 2008; Harris *et al.*, 2006). The next chapter brings together the main management concepts from international construction industries and from the manufacturing sector, providing an objective account of the concepts, relevance to the UK construction industry and showing how they interrelate. Some of these management approaches for performance improvement are: Value Management, Total Quality Management (TQM), Supply Chain Management, and Environmental Management (EM).

From a critical perspective, all such improvement recipes seek merely to make construction companies more efficient in serving the interests of the dominant management elite (Green *et al.*, 2008). Even allegedly enlightened approaches such as EM and TQM are ultimately judged in accordance with their contribution to efficiency and not to sustainability (Goodier *et al.*, 2007; Harty *et al.*, 2007). Industry leaders continually call for change whilst advocating management recipes that reinforce the construction industry's culture of being time, quality and cost focus (Goodier *et al.*, 2007). Calls for generating outputs that are "relevant" to the needs of industry should be raised by construction management research (Goodier *et al.*, 2007; Harty *et al.*, 2007; Green and Lui, 2007).

These management-based approaches for performance improvement are, in different ways, important contributors to performance improvement. This is because, if properly managed and supported by a strategic approach as well as an action plan, they could lead to performance improvement. Therefore, developing a management-based framework for construction industry performance improvement is an issue of major importance which is developed in this thesis.

1.2 The Research Problem

Companies in the construction industry encounter key issues of quality management (or better meeting customer expectations), supply chain management (or more effectively working with suppliers to provide a seamless service to customers) and sustainability (or the challenge of change and structural learning culture towards sustainability) (NAO, 2005). UK construction has been accused of being unsustainable for causing environmental problems ranging from excessive consumption of global resources, both in terms of construction and building operation, to the pollution of the surrounding environment (BRE, 2008).

Construction management research has adopted various management-based approaches to improve organisation analysis and design from the initial project concept throughout the construction stages (Walker, 2007). These approaches are concerned particularly with the integration of the contributors to the process and the way in which decisions are made (Harris *et al.*, 2006). Many studies conducted on EM are generally considered to be divided into three broad groups: (1) The passive model features those organisations that resist change and consider the environmental issues only in terms of cost, overlooking the possibility of new opportunities. (2) The active model is characteristic of those organisations that work just to comply with the regulations. (3) The proactive model is characteristic of those industries that have embedded their environmental objectives at all levels of the hierarchy – from top to bottom – thus widening their competences and responsibilities and changing their mission accordingly (Angell and Klassen, 1999).

In the third case, when the environment becomes a key issue, its pervasiveness at all levels derives from the company's strategies and the continuous improvement process of the ecoefficiency coincides with that of TQM (Arditi *et al.*, 2006). These views are based on the dominant ethos of "serving the needs of industry" (Green *et al.*, 2008). Moving from construction as usual to a Total Quality Environmental Management (TQEM) strategy demands much from an organisation.

The topic of sustainability is seen as a powerful new environmental force impacting on both the project management process and the industry and its clients (Griffith, 2002). Thus, for construction management, the aim for sustainability goes even further than at the design stage of a project. The construction sector is defined as covering the whole lifecycle from planning, design, manufacture, assembly/construction and commissioning of built facilities to their operation, maintenance, refurbishment, deconstruction and re-use (Accelerating change report, 2002). In practice, little or no concern has been given to the importance of selecting more environmentally friendly designs during the project appraisal stage; the stage when environmental matters are best incorporated (Okland *et al.*, 2006; Griffith, 2002). According to the sustainable construction task group (2007), the whole lifecycle of built facilities should be improved to respond to how the industry could add value for its customers.

Since construction activity has a significant impact on the environment, as advocated, it is vital to consider how to improve the environmental performance of organisations in the construction industry (Nash *et al.*, 2006; Griffith, 2002; Love *et al.*, 2000). Hence, many property professionals do not use environmental tools on all projects because of time considerations and the disruption caused by having to take an 'extra step' in the design and specification process (Green, *et al.*, 2007). Contractors would only use such tools either when instructed to do so by clients or because of the contractors' own organisational green agenda (Green *et al.*, 2007). Some argue that for environmental tools to be more widely used, information should also be embedded within commonly used specification programmes such as the National Building Specification (NBS) as well as in stand-alone versions (Okland *et al.*, 2006).

As building projects get larger and more complex, clients are also increasingly demanding higher standards for their delivery (Ding, 2008). Total Quality Management (TQM) has been recognized as a successful management philosophy in the manufacturing and service industries (Hoffman, 2000). It is accepted that TQM can likewise be embraced in the construction industry to help raise quality and productivity (Oakland *et al.*, 2006; Tang *et al.*, 2005; Thorpe *et al.*, 2004). Many quantitative and qualitative studies on construction companies show how TQM can be successfully implemented in the construction industry. The benefits experienced include reduction in quality costs, employee job satisfaction, recognition by clients, work carried out correctly right from the start and closer relationships with subcontractors and suppliers. The research being carried out into the effects of introducing quality initiatives such as ISO 9000 (formerly BS 5750) and TQM suggests that the context in which they operate is confrontational and adversarial.

In the UK construction industry, the recent focus on the environmental concerns mirrors the focus on quality issues in the 1990s (Kibert, 2008). Construction companies who see quality as simply a chore are on the fast track to going out of business (Oakland *et al.*, 2006; Tang *et al.*, 2005; Thorpe *et al.*, 2004). The environmental regulations become stricter and more costly, clients demand more environmentally products, and competitors began to see economic benefits from reducing waste are seen as the main drivers for integrating EM (BRE, 2008; Ding, 2008; Nash *et al.*, 2006; Griffith, 2002; Love *et al.*.., 2000). Construction industry could likewise employ EM as it employed the TQM through the 1990s.

Additionally, due to the cross-functional and holistic nature of sustainable issues, the environmental management of buildings has in some degree to be a part of almost all management systems. Practically, the resemblance between the quality management system (ISO 9000) and the environmental management system (ISO 14000) family is an important driver for the integration of environmental and quality management (Hassan, 2006). Much of the literature on sustainability has therefore multiplied entities rather than narrowing them down (Pearce, 2006). Integrating EM into TQM holistic approach may thus offer meaningful discourse.

Total Quality Environmental Management (TQEM) was proposed by the Global Environmental Management Initiatives (GEMI), in 1991, and the Council of Great Lake Industries (CGLI, 1993). TQEM is composed of four paradigms: (a) Total, involving the entire organization, supply chain, and/or product life cycle; (b) Quality, with its usual “zero defect” definitions, with all its complexities; (c) Environmental, strategic environmental management approach; and (d) Management, the system of managing with steps like Plan, Organise, Control, Lead, Staff, provisioning and organizing as defined by the International Organisation for Standardization (adapted from ISO: 8402, 1994).

A strategic sustainable approach for TQEM could be appropriate as a stand-alone EM leads to the view that the issue of environmental strategy is “slowly being eclipsed” by sustainable development (Kibert, 2008). Hoffman, 2000, suggested that the dual concerns of economic growth and environmental protection should be expanded into trade that includes social equity (Hoffman, 2000). Although TQEM will be used by this study for addressing complex sustainability issues, it may not deliver strategic sustainability by itself. This study does not intend to lead to the assumption that the implementation of TQEM necessarily generates sustainable outcomes by itself since the focus on tools alone can lead to missing the strategic sustainable advantages which are eventually developed by competitors (Barret, 2008b). Hitherto, the principle of continuous improvement, on the economic, social and environmental dimensions, is at the heart of TQEM leading to performance development towards sustainability (Hassan, 2006).

TQEM analysis may reveal that construction companies are actually failing to meet the sustainability objectives. This is because the positive quality and environmental standards and tools are not sufficient to cover the sustainable strategy targets. Marring the EM and TQM within a strategic sustainable approach could improve the construction industry performance. To this effect, the research gap is stated in the following section.

1.3 The research gap

Existing construction management research indicates that, despite the wide interest in improving the construction industry quality and environmental performance towards sustainability, the empirical debate concerning addressing these needs through a management-based approach is still not settled. The tradition of TQEM critical theory has, to date, been largely ignored within the construction management research community (Green and Lui, 2007).

While the relationship between the natural environment and quality management has received considerable attention, researchers are only beginning to explore how these interests can best be integrated. The management and benefits of quality and environmental management have a number of theoretical similarities, suggesting that a TQEM framework may be applied to organisations (Angell and Klassen, 1999).

The available UK construction performance improvement schemes were not built to exacting environmental standards; they use environmentally intrusive and damaging construction processes which risk alienating communities or bringing the whole construction industry into disrepute to meet the current sustainability challenges (Green *et al.*, 2007). Many of the available construction performance improvement initiatives focus on quality, environmental and sustainability improvement, but conclude with setting out the objectives rather than how to achieve them (e.g. a Civil Engineering Environmental Quality Assessment and Award Scheme (CEEQUAL), BRE Environmental Assessment Method (BREEAM), The Leadership in Energy and Environmental Design (LEED), Code of Sustainable Homes, 2008).

It should be noted that most of the TQM, EM and TQEM related studies were conducted overseas. Some of these studies emerged in the manufacturing sector. Egan, 2004, argues that it is possible to adapt some manufacturing management techniques to the construction industry. Most of the modern day management initiatives in construction generally derive from the same sources credited with quality initiatives in manufacturing i.e. TQM, ISOs, Baldrige quality awards, and Six-Sigma (Arditi *et al.*, 2002). From research conducted overseas, the concept of TQEM is widely used in the USA construction industry (Callan *et al.*, 2006).

One could argue that most of these researchers have traditionally focused on the technical features for assessing construction projects outcomes and have tended to lack a strategic sustainable perspective (Kibert, 2008). However, recent interest in construction performance improvement has resulted in global research initiatives that aspire to provide an understanding on Environmental Management (EM) and Total Quality Management (TQM) (Oakland *et al.*, 2006). Total Quality Environmental Management (TQEM) has emerged, in the manufacturing sector, from integrating EM into TQM holistic approach (Ding, 2008).

While most of the construction management studies are project based (Fellow *et al.*, 2002), the current research looks at management principles and techniques applied to the day-to-day problems facing a business in the construction industry. It covers: a) sustainable business strategy, b) industrial relations, c) TQEM integration (business and processes), and d) performance management and changing business culture considerations.

Construction management research has tended to be limited to the narrow domain of instrumental rationality (Ding, 2008; Green and Lui, 2007). In other words, the dominant research is to a form of rationality concerned with the most efficient means of achieving a given end (Knight and Ruddock, 2008). Economic externalities such as pollution and the human/social cost of regressive management regimes consistently fall outside the adopted frame of reference (Green *et al.*, 2008; Dainty *et al.*, 2007). Management improvement recipes such as value engineering, benchmarking, business process re-engineering and lean construction all demonstrate the same narrow fixation with instrumental rationality (Goodier *et al.*, 2007; Green *et al.*, 2008). They echo the oratory of Taylorism* whilst propagating the supposedly neutral aims of 'improving efficiency' and 'eliminating waste' (Barrett, 2008).

The limitation of construction management research to issues of instrumental rationality is shaped by the broad ideology of neoliberalism (Green *et al.*, 2008). The over-riding assumption is that TQEM could improve construction industry performance towards sustainability and should be investigated. Thus, this belief remains remarkably intact despite an absence of any supporting research evidence.

At present, there is no single study on sustainable construction that applies TQEM in the UK construction industry. Instead, there are a variety of policies, regulations, performance standards, guidance documents and voluntary initiatives that apply to many issues and audiences (Oakland *et al.*, 2006). Although it may be impossible to subsume all of these into one strategy, there is a pressing need for clarity on shared aspirations, priorities, actions, milestones, and deliverables to move closer to achieving sustainable construction (Green *et al.*, 2008). Existing research on construction management has not resolved the debate on how to improve construction performance towards sustainability (Harty *et al.*, 2007; Kibert, 2008). This indicates that despite the wide interest in improving quality, environmental and sustainability for the UK construction, construction companies are short of management-based strategy for performance improvement towards sustainability (Kibert, 2008, Harris, 2006; Bennett, 2003).

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* Taylorism is a theory of management that analyzes and synthesizes workflows, with the objective of improving labour productivity (Barrett, 2008).

TQEM is a total applied system approach and an integral part of high level strategy. It works horizontally and vertically across functions and departments, involving all employees top to bottom, and extends backward and forwards to include the support chain and the customer chain (Hoffman, 2000). It attempts to maximize the competitiveness of an organisation through continual improvement through the whole life value analysis of the project (Wagner, 2007; Nash *et al.*, 2006). It is anticipated that by driving TQEM, according to Strong and Hemphill 2006, construction industry could achieve,

- a step change in the sustainability of the construction industry (TQEM supports mainly the environmental dimension of sustainability which in turn influence the economical and social dimensions);
- continuous improvement;
- responses that take forward change in the construction industry in order to enhance efficiency; and
- long-term certainty, so that companies and the UK construction industry can innovate and lead internationally in products and services for sustainable construction.

With this consideration in mind, the current study integrates EM and TQM principles for addressing construction sustainability objectives. The outcome of the study contributes to filling a gap in current knowledge in this area of academic interest, and provides additional insights to those provided by previous studies. The project uses a UK-based sample of construction contractors. This study provides a TQEM approach that could be useful to contractors who may be interested in TQEM as a replacement or complement for performance-improvement towards sustainability.

1.4 Research Questions

According to the gap in knowledge found in the literature, the research questions are formulated as follows:

- Is there a demand for TQEM towards sustainability for the UK D&B principal contractors?

- What are the key factors for integrating TQEM for D&B principal contractors?
- What impacts could TQEM have on contractors' organisational and project levels?
- Is it possible to develop a TQEM framework for novated D&B principal contractors?

1.5 Motivation for the Study

This section highlights the regulatory, managerial and procurement contexts which have prompted the current investigation. To reduce its damaging impact on the environment, construction companies have to comply with the increasing number of quality and environmental regulations. Apart from the purely practical implications of compliance, there are some interesting questions concerning construction quality, environmental and sustainability's performance improvement through an integrated management approach on one hand and on the other hand whether this context could be linked to construction procurement.

As the built environment consumes 50% of the energy within the UK, the construction industry has a significant responsibility for designing and constructing buildings that contribute to human well-being with reduced energy consumption and carbon dioxide emission during the construction works' lifecycle (Oakland, 2006). To meet the Kyoto target of reducing carbon dioxide emissions by 20% by 2010 the UK government has introduced a number of measures, report and standards to achieve environmentally conscious buildings and promote sustainability within the built environment. One of the devices through which to do this is the Building Regulations, which were originally introduced to ensure public health and safety, but are increasingly seen as a tool for limiting the environmental impact of the built environment on natural resources (Greenwood and Hamza, 2009).

For improving their impact on the built environment, construction companies are encountered by stricter building regulation and taxation (the 'stick') and tempted by recognitions and awards (the 'carrot'). In 2006, the government introduced performance-based calculations for building energy consumption. New landfill taxations for buildings came into force in 2006. The latest version of the Civil

Engineering Environmental and Quality award (CEEQUAL, 2008) developed a list of environmental and quality objectives. It aims to promote improving and linking a project quality, environmental and sustainable performance. BS ISO 15392 (2008) was developed to provide general principles for sustainability in building construction of the whole construction cycle (design, construction procurement, operation, end lifecycle).

The response of the UK construction industry to the recently-enforced environmental regulations was one of 'blind panic' (Greenwood and Hamza, 2009). A survey on UK contractors' design practices to assess the impact of current energy conservation policies and legislation stated that 80% of the surveyed sample indicated that the new regulation, such as Part L for energy efficiency (compared with government white papers and good practice guides), had the foremost impact on the design and construction of buildings (Brown *et al.*, 2007). The response of the Department of Communities and Local Government (DCLG) was that stakeholders perceive building regulations to be driven by reactions to current hot topics and as "being increasingly politically, rather than practically, driven". The impetus was "getting a tick in the box for Kyoto" which was accomplished with "the usual political rush to be seen to be doing something without sufficient regard for implications" (DCLG, 2007).

Thus England and Wales, like many countries, aim to move away from prescriptive building regulations to standards where compliance is achieved by the performance of the end product (the finished building). The appeal of the management-based approach is as much about introducing a regime that overcomes problems of overly-rigid rules and inflexible enforcement as it is about regulating for results (May, 2003). It is the management processes, by adequate organisation, actions and decision, taken or led by the actors involved at the different stages of the building project, which aims to optimize the design, construction and/or operation, in order to improve the environmental, quality and sustainability performance of the building (ISO/DIS 21931, 2008). The management processes interfere with the construction characteristics and may influence all building performance aspects.

The concepts involved in managing buildings sustainability are highly complex and under constant study. There are no definitive methods for achieving sustainability or confirming its accomplishment (Hassan, 2006). Nevertheless, CEEQUAL (2008) suggested that linking a project quality, environmental and sustainable features may be useful when considering the completeness and validity of claims of, or calls for, sustainability. CEEQUAL, also, has linked the move towards sustainable performance with the design-and-build procurement route.

The BS ISO 15392 (2008) aimed to set out the objectives for sustainability in building construction and from these derives general principles. This standard suggested further research on a management-based approach for deriving the change. According to ISO/DIS 21931 (2008) the development of further research on building sustainability should be driven by: the need to meet the construction industry market demand, the shift from single management approach to more integrated management techniques, and the recognition of the benefits of proactive approach. A management-based framework could improve a project quality, environmental performance, and may enable decision makers to apply sustainability principles in their decision making (Green *et al.*, 2007).

In England and Wales, all projects, whether new-built or refurbished, must obtain planning permission to ensure conformity of the project with its cultural and societal context, before it is passed on for building regulations compliance checks. This had historically left issues of compliance with building regulations unresolved until the later project stages (Greenwood and Hamza, 2009). The UK Building Regulations and their accompanying 13 parts (arranged alphabetically, and known as 'Approved Documents') facilitate the understanding and implementation of issues concerning safety of buildings, people and their living environments in the design phase. Building regulation revisions are normally incremental but Part L (2006), for example, is more radical, bringing the onus of compliance to the fore chronologically. For the first time in the history of such legislation there is a need to comply with a building regulation before applying for planning permission. This is because most of the building quality and environmental issues are design and construction variables.

The quality and environmental attribution in design are the main components in submitting the building for planning approval (Greenwood and Hamza, 2009). Any later changes will necessitate a resubmission to planning authorities, which would clearly result in a loss of time and money to the whole project team. The major impact of these regulations, initiatives and environmental sensibility will fall upon many parties, for example, architects, building services engineers, main contractors and specialist engineering contractors. The degree of responsibility and risk, and where they fall, will depend in part on the project's particular procurement and contractual arrangements. This research seeks the views of contractors' representatives as key parties involved in these issues which should be investigated.

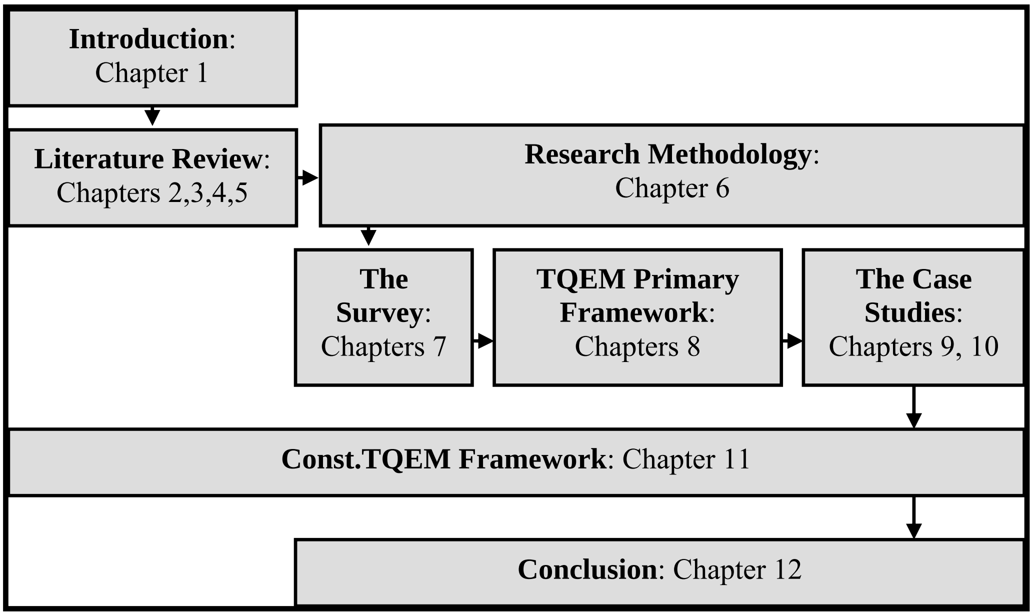
A number of recent reports have highlighted changes in the way buildings are being procured in the UK (explained in Chapter Two). The traditional method of procurement presupposes that designs are completed before contractor involvement. In contrast, Design-and-Build relies upon a certain amount of concurrency in design, procurement and construction (Morledge *et al.*, 2006). According to the Consultants' Performance Indicator Report Design-and-Build as a procurement route increased between the year 2002–2003 from 12% to 30% of contracts (by value) while traditional contracts decreased from 35% to 29% from 2002 to 2003 (Association of Consulting Engineers, 2003). The RICS survey of building contracts in use during 2004 reported a decline in what could be described as 'traditional' methods, with Design-and-Build accounting for just over 40% of total workload value, and partnering agreements featuring much more heavily (RICS, 2007). Data based on a more extensive survey support this, and indicate that together 'pure' (20%) and 'novated' (26%) Design-and-Build procurement account for nearly half the value of proposed construction projects (RICS, 2007).

The increasing use of collaborative working methods, through integrated management methods and Design-and-Build procurement, could lead to the reduction in the costs of striking deals (Greenwood, 2006). Greenwood expected that further advantage of more productive and innovative industry could occur through an integrative procurement practice and management-based strategy. It is these regulatory, managerial and procurement challenges, and those for the decision-makers in construction companies that have motivated the research to develop a TQEM framework for main contractors within a Design-and-Build procurement strategy. This involves three levels of investigation: TQEM management context (the survey), procurement context (the case studies), and developing a framework for TQEM implementation for business and project levels.

1.6 Layout of the Thesis

The thesis consists of twelve chapters. The present chapter has introduced an overview of the research background, presented the research problem and the research gap. The aim and overall objectives of the research were defined. As can be seen in figure 1-1, the layout of the thesis in terms of the constituent chapters are summarised in the remainder of this chapter.

Figure 1-1: The Research Structure



Chapter Two presents the UK construction industry; overview, economical, environmental, and social contribution to the built environment, environmental and quality principles, procurement routs, and stakeholders. These sections establish this research problem; (D&B main contractors demand for a management-based solution for environmental and quality performance improvement from procurement, regulatory, and problem of intervention perspectives). The chapter establishes novated D&B main contractors' demand for a management-based solution in the areas of quality, environment and sustainability.

Chapter Three reviews a range of the UK construction performance improvement schemes in order to explore the extent to which they were able to provide robust process that enables assessment of overall quality, environmental, and sustainability. Notable amongst the proposed solutions is the concept of considering construction as a manufacturing process through the application of its management-based techniques.

The discussion points out TQEM as a general term for a broad range of activities aimed at improving contractors' performance on the corporate and project levels.

Chapter Four discusses the evolution of EM, TQM, and TQEM. This reveals that the proactive approach of EM coincides with TQM. This chapter mandates the potential role of TQEM in improving contractors' performance on the corporate and project level. The chapter also highlights deficiencies in past TQEM literature for addressing previous TQEM studies shortcomings and what remains to be studied by this research.

Chapter Five mandates the role of TQEM towards sustainability in construction industry and concludes to this research framework. The research framework encapsulates the literature review concluding remarks and establishes the bases for the research methodology chapter.

Chapter Six introduces the research design and methodology adapted to achieve the aim and objectives of the study. It also presents the research design, the hypothesis development, the selection of the appropriate data-collection methods and sampling-frame.

The chapter suggests taking multiple reality stances as an appropriate ontological approach for extending the scope of TQEM. The reason is that TQEM subject matter does not exemplify all of the ideal characteristics of either paradigm (quantitative, and qualitative). This is because TQEM is not only confined to facts (quality and customer satisfaction issues and environmental indicators) but also includes the participants' perceptions (i.e. managers' commitments and companies' culture). The design and administration of the questionnaire and the case studies protocol are explained.

Chapter Seven presents the survey results and analysis. The survey was on a non probability sample of main D&B contractors. The questionnaire design includes four areas; (a) Company background; (b) The demand side and the level of implementing or addressing TQEM towards sustainability; (c) The key factors for integrating TQEM (including the standards and techniques being used, linkage to constriction stages, the associated benefits, barriers contractors have experienced); and (d) Performance measurement towards sustainability. . The data is collected and analysed using CPSS software.

Chapter Eight refines TQEM primary framework which would hopefully be sufficiently general for implementation purposes. This chapter elaborates on the survey findings, establishes the framework's design criteria. It builds up TQEM key successful factors, TQEM strategic levels towards sustainability, adding value approach, and TQEM key indicators.

The key areas of corporate-level primary TQEM framework are categorised into six phases starting from construction companies' management commitment throughout the following phases: (a) strategy formulation, (b) ensuring compliance, (c) management system implementation, (d) TQEM integration, (e) sustainable balanced scorecard and (e) continual improvement.

Chapter Nine introduces the findings of the three case studies. Through interviews, observations, and documents analysis, the research investigates the company background, TQEM implementation and the primary framework viability.

The content frame and coding is presented in this chapter. This provides the pivotal link between collecting data from managers and developing an emergent theory to explain these data. Understanding the case studies' informants' professional standing and the significance of their comments are enhanced to ensure the primary TQEM framework external validity. The case studies also investigate the feasibility of the proposed implementation framework in terms of its strengths, weaknesses, simplicity and practicality.

Chapter Ten involves cross-case examination. TQEM impact on contractors' management, performance, and procurement is analysed. TQEM key successful factors on the project-level are discussed.

The analysis will be primarily conducted through cross case examination to look for differences and similarities, thus ensuring that important lessons were learned. The chapter highlights the initiatives implemented, and TQEM implications for management, design and decision making, bidding documents, the risk of non-compliance, liability, client satisfaction, and sustainability. It also discusses the problems associated with TQEM implementation and project-level TQEM key factors. The framework then will be developed further through the provision of rich, thick detailed description out of the case studies.

Chapter Eleven presents the Const.TQEM framework as a management tool towards sustainability for D&B contractors. Const.TQEM is a standardized methodology for integrating TQM and strategic EM into a comprehensive lifecycle approach to construction project. Const.TQEM includes a broad range of activities aimed at improving contractors performance (corporate and project levels). It offers general engineering approach to improve the design, operation, and environmental quality of the building.

The framework phased approach is explained with implantation guidelines on how to use the framework. The framework is intended to be non-prescriptive, and the adoption of Const.TQEM initiative to be dependent upon the demands and priorities established by the contracting company. Guidelines for using the framework were provided. The framework provides an interactive approach between the different parties involved in D&B procurement strategy.

Chapter Twelve provides the research conclusion. The chapter includes a critique for this study and suggestions for further research. It highlights the discussion over the conflict between economic and environmental needs, the similarities between quality management and environmental management systems and the effectiveness of enhancing Const.TQEM towards sustainable construction.

This chapter highlights the reasons; why this research adds to the scholarly research and literature in the field of construction management, how the study helps improve D&B contractor's practices, why the study will improve D&B contractor's quality and environmental policy and performance. Although the idea is simple, the task is substantial and further research is suggested.

CHAPTER TWO

THE UK CONSTRUCTION INDUSTRY

CHAPTER TWO: THE UK CONSTRUCTION INDUSTRY

2.1 Introduction

The UK construction industry is complex; operating within ever-changing legislative needs, new materials, technologies and constant demands on UK resources both natural and human (Watson *et al.*, 2008:6). Within this chapter the key components of the UK construction sector are explained. These are the key sectors, characteristics, current trends, contribution to the built environment, the environmental principles, the quality attributes, construction stakeholders, and the procurements routes. These key elements are not dealt with in isolation, however, for in reality they are not mutually exclusive, nor are they independent from other management-based key tools, initiatives and techniques for contractors' performance improvement (Love, 2000:321).

Starting by setting the scene of the UK construction industry, this chapter aims to analyse the construction industry as a first step towards understanding the industry structure and staking-out a solution for improving contractors' quality and environmental performance. Porter (2008) suggested six typical steps in industry analysis: a) defining the industry, b) identifying its marketing segment and grouping its participant (i.e. clients, suppliers, competitors etc), c) underlining the drivers, weaknesses and strengths, d) studying the industry systems and structures, e) analysing current and likely future trends, and f) identifying aspects requiring improvement. It is important then to start from the significance of the UK construction industry, its definition and its contribution to the built environment to demonstrate the need for performance improvement and establish a potential solution.

An integrative and holistic approach has been adopted in this chapter, with some topics by necessity being introduced in isolation, but with an overarching theme. This enables understanding on how the topic areas can impact upon contractors' quality and environmental performance. The chapter demonstrates novated D&B contractors' demand for improving their quality and environmental performance through regulatory context, procurement context and problem with intervention. The rationale for suggesting a management-based approach such as TQEM for performance improvement is based on the fact that improving main contractors' quality and environmental performance will require corporate and operational best practice management principles, tools and techniques in an integrative and holistic way.

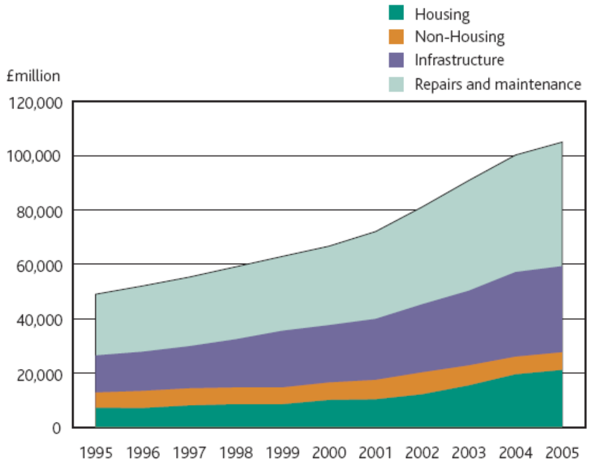
2.2 Overview

Construction is a complex undertaking. This section overviews the UK construction industry sectors, characteristics, and the current trend of environmental management and sustainability.

The construction industry is large, complex and covers a wide range of different products and activities (NIO, 2007). The UK construction industry is characterized as highly fragmented; made of a large number of relatively small companies which join together on a temporary basis to undertake particular projects (Harris *et al*., 2006: 1). Figure 2-1 illustrates contractors' outputs over 11 years from 1995 and indicated nominal growth of 14%. The repair and maintenance work appears to be the highest contribution. Modest growth at these levels is sustainable over the long term. There is an increase in the mixed use development due to the increased complexity of the product that requires greater use of main, different sector, contractors and large specialist sub-contractoring companies (Callcutt Review, 2007: 175). Construction sector output comprises two types of work, the private sector, and the public sector. The public sector appears to have a leading role in promoting sustainable construction as a major client and major projects' output (Watson *et al.*, 2008:77).

There is an increasing number of building contractors who undertake different building works such as civil engineering, infrastructure, industrial and commercial work, house building and repairs and maintenance (The Callcutt Review, 2007: 176). The nature and structure of the contractors and subcontractors supply chain makes it very difficult to establish a quality and environmental culture and generally disables any proactive quality and environmental management approach (The Callcutt Review, 2007: 176).

Figure 2-1: Construction sectors output



(Source: Callcutt Review, 2007: 175)

Neither the sector nor the size of construction firms are rational barriers to the implementation of an appropriate management-based approach for performance improvement (Watson and Griffith, 2004: 236). Despite the diversity of work handled by a construction company, the corporate procedures apply to all projects in varying degrees (Chung, 2002: 5). Typical examples are tendering, procurement, document control and record keeping. This may be the reason why the available quality and environmental standards and management systems are set up to standardize these corporate procedures with provision for preparation of plans to cover the characteristics and specific operational requirements of a particular project. Therefore, for the application of this research, no special consideration is given to the construction companies' market segment. Unfortunately, the industry's significant output is associated with a major negative impact on the built environment which requires contractors' performance improvement.

A management-based approach for performance improvement should encapsulate the key aspects of project management, construction management, and procurement practices (Watson *et al.*, 2008:6). Watson (2008: 75) described some differences between construction management and project management. Construction management usually consists of a set of tasks that are repeated within a set of reliable processes. Project management is related to the activities of a 'one off' specific project. Harrison (1995: 2) described the traditional type of construction management as not being able to handle projects effectively due to project characteristics (one of a kind, on site production, temporary organisation). However, according to Naoum

(2001: 3), project management is a more challenging process. More peculiarities, such as fragmentation, risk and uncertainty, retention and little capital accumulation, and the high degree of regulation, add to the complexity of the UK construction industry. This study is a construction management research on D&B main contractors in order to overcome formalized separation between design and production, and a lack of formal production management.

Sustainability is becoming an important theme in the construction industry as the government policy is to encourage sustainable activities across a wide range of areas, including land use, materials, water supplies and energy needs (Keynote, 2008). A combined framework incorporating both environmental assessment and environmental sustainability is presented in the Green Building Challenge (Larrson and Cole, 1998). Relevant environmental and social requirements may be specified in the tender documents and used in the assessment of tenders provided that; they are sufficiently well defined to allow both bidders to understand the requirement and the factors to be assessed during contract award; and they are compatible with community law (Morledge *et al.*, 2006: 64).

The environmental and sustainability current trend, in construction, comprises stricter building regulation and taxation (the 'stick') and several awards' schemes for recognition and competitive advantages (the 'carrot'). For example, in 2006, the government introduced performance based calculations for building energy consumption (Part L). New landfill taxations for buildings came to force in 2006. The latest version of the Civil Engineering Environmental and Quality award (CEEQUAL, 2008) developed a list of environmental and quality objectives (explained in Chapter Three). CEEQUAL aims to promote improving a project quality, environmental and sustainable performance. BS ISO 15392 (2008) was developed to provide general principles for sustainability in building construction of the whole construction work's lifecycle (design, construction, operation, end lifecycle). The Code for Sustainable Homes will ramp up the standard levels further.

The industry approach to the environmental and sustainability problems appears to be reactive (Harrington *et al.*, 2008)*. The adoption of environmental and sustainability

* The Reactive Position means that the environmental problems are corrected once they have been created (Harrington *et.al*, 2008).

practices has been viewed from a perspective heavily influenced by legal consideration (Klassen, 2000a; Curkuvic, 2003; Curkovic and Srouf, 2006). The proactive approach may be a solution for the retroactive dynamic nature of the environmental and sustainability laws (Curkovic and Srouf, 2006).

This research addresses the current trend of increasing sustainability and environmental challenges encountering the UK construction industry. Nonetheless, other trends, such as developing new building techniques and materials, skills shortage, and rising energy prices could be linked to the contractors' poor quality and environmental performance. Further research and development for more environmentally friendly building techniques and materials is currently underway. The challenge for the construction industry has become how to introduce much more original thinking into design and construction so as to produce buildings that are well-built and which meet policy criteria in terms of social, economic and environmental sustainability.

2.3 The UK Construction Industry Impact on the Built Environment

UK construction influences and is influenced by the economic, social and environmental trends of the nation. The construction sector is very important for the UK on economical, social and environmental levels. The size of the UK construction industry in the UK is impressive, in terms of output, employment and contribution to the built environment. Construction companies have enormous financial power but they also account for a large proportion of resource use and environmental damage in the UK, and have an enormous impact on people's lives. The impact of the property and construction sectors on the built environment can be classified into three main areas: economic, environmental and social, as discussed below.

2.3.1 Economic impact

The end product of construction activity is the built environment, made up of the national infrastructure and residential, commercial, industrial and public buildings, which is estimated to account for some 70% of current UK manufactured wealth. The value of built assets in the central government sector alone is estimated at just under

£161 billion (DEFRA, 2006). This section highlights the economics of scale and benefits of growth in the UK construction industry.

The UK construction industry makes a significant positive contribution to the economy. Over recent years the UK construction industry has experienced high levels of growth. The construction, building materials and associated professional services together account for between 7% and 8% of Gross Domestic Product (GDP) (sustainable construction task group, 2007). The figures presented in table 2-1 indicate that although outputs increased year-on-year throughout the review period (2005 to 2008), the rate of growth decreased each year , from 11.9% in 2005 to just 4.5% in 2008 (Keynote, 2008: 12).

Table 2-1: The UK construction industry

	2002	2003	2004	2005	2006
Total	74.7bn	83.6bn	93.3bn	102.4bn	107.01bn
%Change year on year	-	11.9	11.6	9.7	4.5

Source: (Construction Statistics Annual, 2007)

However, the economic downturn appears to be hitting the construction industry. The industry faces impact on output prices and a 1% rise in inflation between 2005 and 2015, according to a report by the Office of Government Commerce (OGC, 2008). The low inflation rate in the past five years has provided a generally favourable financial background for the construction industry in general and the house building in particular. Table 2-2 illustrates the inflation figures over the past five years.

Table 2-2: UK rate of inflation

	2002	2003	2004	2005	2006
%Inflation	1.8	1.6	2.9	3.0	2.8

Source: (National Statistics, 2008)

This emphasises the importance of the sector growth. Two types of construction growth were suggested, namely: organic growth and acquisition. The two approaches are not a risk free*. Organic growth entails increasing the scale and efficiency of

* High growth strategies risks are: the company overpaying and vulnerability to any downturn in the market, acquisitions leads to overpaying but its rapid corporate growth brings with it the hidden liabilities of the acquired company due diligence, unpleasant surprises on large scale buildings defects and unreported cost increases on major projects, are common (Callcutt Review, 2007)

existing operations and means (Kibert, 2008: 21). This requires more investment in Design Innovation and Research & Development (R&D) (Callcutt Review, 2007: 80), for example on new construction methods or the cost effective delivery of sustainability over a much larger turnover, and thereby reduce the project cost.

Organic growth increases the market profile through 'brand building' as a way of achieving higher sales through customer loyalty or a cost effective price premium through a reputation for quality, environment and sustainability (Kibert, 2008: 22). It is interesting to note that a few smaller companies, such as Octagon and Urban Splash, have managed also to create niche reputations based overwhelmingly on their innovation and quality (Callcutt review, 2007: 69). For safer economic growth a management-based approach, such as TQEM, could drive an organic growth. Possible reasons might be TQEM ability in brand building, customer satisfaction, cost-effectiveness and reputation of quality, environment and sustainability.

2.3.2 Environmental impacts

Besides being a key driver of economic performance, the construction industry is arguably one of the most resource-intensive and environmentally-damaging industries in the world (Kibert, 2008: 21). Construction accounts for 40% of the total flow of raw materials into the global economy (Green *et al.*, 2007).The majority of these materials are stone, gravel, sand, clay, iron ore and other quarried products. Their production and processing impacts the landscape and can cause air pollution, toxic runoff into watercourses and loss of forests and agricultural land. Construction and operation of buildings also account for 25% of all virgin wood use, 40% of total energy use, and 16% of total water withdrawals and generate enormous quantities of solid waste (sustainable construction task group, 2007).

There are a number of environmental impacts associated with construction. Some of the most significant, according to sustainable construction task group, are presented in table 2-3. These impacts offer an indication of the dramatic problems that the construction and development industries pose for the UK natural environment. Each new development carries with it a new and unique set of impacts that, if sustainability is to be factored in, must be mitigated and minimised.

The UK Government policies are designed to ensure that, as far as possible, all new developments are more sustainable. The Government target of zero carbon buildings by 2016 is driving the change as explained later in this chapter. Zero-carbon, energy efficiency solutions should be given a high importance for improving the UK construction industry environmental contribution. Yet achieving sustainability in the UK construction means more than just reducing its environmental impacts. Contractors are placed to become active partners in social progress, community regeneration and initiatives for a better quality of life, as discussed in the following section.

Table 2-3: The environmental impact of the UK construction industry

Land converted from rural to urban use	**Minerals extracted**	**Construction and demolition waste generated**	**Commercial and industrial noise complaints**	**Water pollution incidents**	**Emissions of greenhouse gases**	
6500 ha	260 million tonnes	72 million tonnes	20%	21%	70% of the UK's total	49% operation of buildings

(Source: Sustainable construction task group, 2007).

2.3.3 Human and social impacts

The construction industry is a 'high impact' industry on human and social levels. The principles of corporate social responsibility (CSR) apply to all businesses, regardless of industry. Yet, the construction industry contributes significantly to the built environment because its influence on social and environmental issues is far greater than that of many other industries (Green *et al.*, 2007). A dichotomy exists between the need to maximise shareholder value, and the need for a company as a social entity to act in a socially-responsible manner (Callcutt Review, 2007:69).

Ultimately, though, if construction companies want to be recognised as being socially responsible, they will have to be able to demonstrate excellence at their core skill of delivering a high quality product and service to their purchasers. Construction and the built environment shape the lives of UK citizens through their impact on: a) the delivery of improved public services such as health, education and transport, b) social cohesion and stability, such as the effect of rundown environments on crime, poverty and health, and c) the natural environment through, for example, the growing risks associated with carbon dioxide emissions (DEFRA; UK Climate Change Programme 2006).

The construction sector employs approximately 1.5 million on-site workers. Including all other associated employees puts that figure closer to 2.3 million, as can be seen in table 2-4. With a steadily rising UK population (table 2.5) and the Government projecting a rise in the number of households between 2005 and 2021 of 3.8 million, property development appears to be assured of a healthy future.

Table 2-4: Number of employees in the UK construction industry

	2002	**2003**	**2004**	**2005**	**2006**
Employed	1,294	1,274	1,308	1,356	1,375
Self-employed	671	714	785	818	841
Total	1,965	1,988	2,093	2,174	2,216

(Source: DTI: Construction Statistics Annual, 2007).

As well as its economic significance, the UK construction industry is one of the UK's major employers. The majority of private contractors employ more than 4 people. Nevertheless, in terms of the value of the work done, the industry is dominated by a small number of large companies. In 2006, the UK construction industry directly employed about 2.2 million people. There are also a large number employed indirectly with materials and components manufacture, plane and vehicles builders (Bennett, 2000: 33). As can be seen in table 2-5, the population, in 2006, stood at just over 60 million people arise of (Keynote, 2007).

Table 2-5: The UK resident population

	2002	**2003**	**2004**	**2005**	**2006**
Females	30,281	30,359	300,446	30,563	30,642
Males	28,832	28,963	29,108	29,271	29,382
Total	59,113	59,322	59,554	59,834	60,024

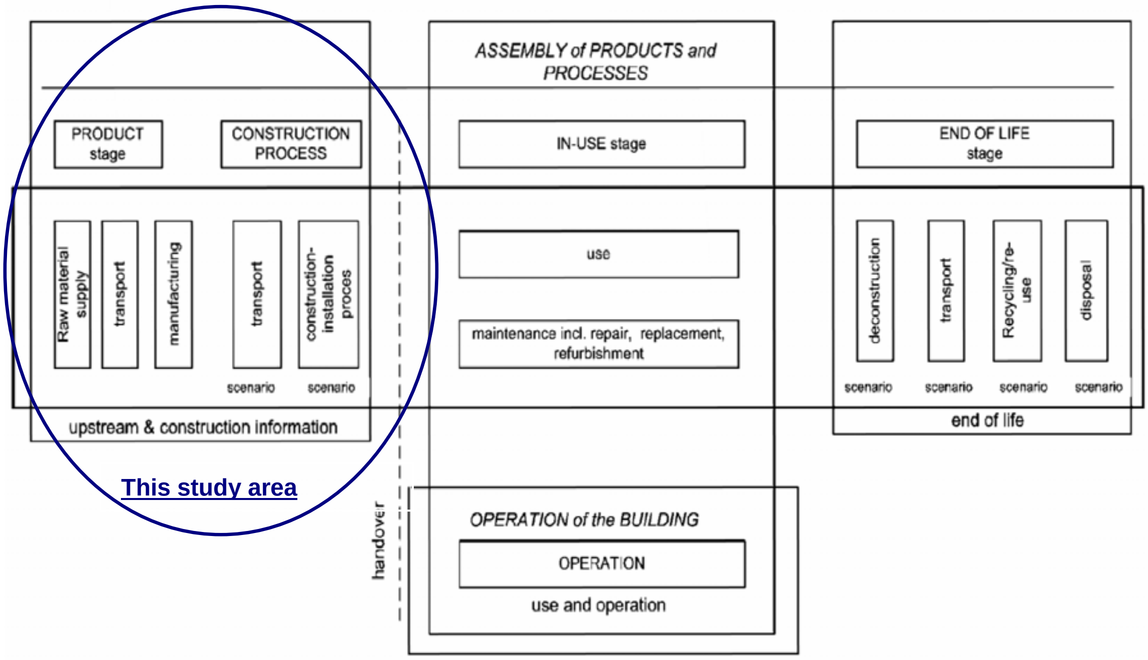
(Source: National Statistics, 2007)

On the downside, the construction sector accounts for 9% of deaths and major injuries (Achieving Excellence Action Plan, 1999). Improved health and safety can help encourage new recruits into the industry. Construction workers in England suffer eight times more fatal injuries and three times more non-fatal injuries than those in other industrial sectors (sustainable construction task group, 2007)*. To eliminate the construction industry's damaging impact on the built environment, a well-managed construction is required to improve the industry's quality, environmental and sustainability performance.

2.4 Environmental Principles throughout a Construction Work's Lifecycle

At their broadest, environmental considerations need to be built-in at each stage of the project lifecycle. According to Achieving Excellence in Construction, 2007, project lifecycle stages are (Figure 2-2); a) Business justification (the business case); b) contract amendment; c) design stage, including planning consents; d) construction process; e) operation and management; and f) disposal and reuse.

Figure 2-2: Structure of the life cycle stages of a building



(Source: ISO/DIS 21931, 2008).

It is important that the pursuit of design environmental, quality and sustainability features are not undertaken in isolation but is integrated in the overall process,

* The Health and Safety Council reported a 34% increase in British worker fatalities during 2000/2001 compared to the previous year and of the 295 fatalities reported, a massive 106 were in the construction industry (sustainable construction task group, 2007)

bringing together client leadership, integration of the project team and continuous improvement (Watson and Griffith, 2004:15). The environmental and quality performance of the construction industry is related to its characteristics and functions, with the building being: i) an end-use product and an integrated assembly of products, ii) a system in operation, and iii) a place to live and work.

2.4.1 A building as an end-use product

A building itself can be considered as an end-use product. A building physically consists of various elements such as construction materials and components, which are parts of a building and its technical systems (ISO/DIS 21931, 2008). Therefore, similar to the manufacturing industry, a building can be considered as an integrated assemblage of component products which are manufactured, used and disposed of, according to their service life (Green *et al.*, 2007).

The method of assembly is customized depending on the project's specific requirements which are set at an early stage in its lifecycle. According to Achieving Excellence in Construction Procurement Guide: 3, 2007, the design quality definition was extended to include not only the style or appearance but also incorporates the key requirements of the stakeholders and business, functionality, and whole-life value in relation to maintenance, management and flexibility, health and safety, sustainability and environmental impact. The development of environmental and quality performance of buildings can be based on the aggregation of the impact improvement of the major component products and services, assuming the availability of life cycle assessment (LCA) data for the components over the entire life cycle, as illustrated in Figure 2-2.

2.4.2 A building as a system in operation

A building can also be considered as a system in operation. As can be seen in figure 2-2, through its operation during the utilization stage, a building provides a number of services to its users as well as conditions appropriate for living, working, studying, provision of health-care, leisure activities, etc. The provision of these services involves input and output flows (ISO/DIS 21931, 2008).

The environmental and quality performance of the building relates to the services and conditions provided to users, when it is considered as a system in operation (Bennett, 2000: 33). Under these circumstances, a building is linked to infrastructures which also require energy, water, and transport that generate environmental impacts. Consequently, the quality and environmental performance of a building relates to input and output flows that a building generates as a system in operation. The impact of these operations on the built environment could be improved by focusing on the decision-making process at design stage.

2.4.3 A building as a place to live and work

A building can be considered as a place to live and work, where the indoor and outdoor environment and the building's effects on the surroundings will have an impact on the well-being of the users, and on other buildings and users of the neighbourhood (ISO/DIS 21931, 2008). Therefore, the environmental performance of the building influences the comfort and health and quality of life of its users, such as occupants, site workers, maintenance staff and neighbours and other interested parties, over the building's lifecycle. Also the building impacts upon the local environmental conditions, e.g. wind loads, noise, shading, etc. When a building is considered as a place to live and work, indoor environment and localized environmental impacts can be included in the method of the assessment of the environmental performance of a building.

Methods for improving construction industry quality and environmental performance need to take particular account of planning, design, and construction stages of a project. Quality and environment considerations should be applied from the start of the project life cycle in order to achieve an efficient and sustainable solution. This will result in improving build quality and environmental features, functionality, and impact on the built environment.

For the application of this study, the research focuses on the circled area in figure 2-2, which includes the design and construction stages. On one hand, this allows the viewing of construction as a manufacturing process. On the other hand, focus should be given to the planning and decision making criteria from the very beginning to improve the whole life cycle impact of the building on the built environment. However, the common view is that despite the negative impact on the built environment, the implementation of these environmental principles are very slow compared to employment of quality management systems (Curkovic and Sroufe, 2007;

Lam and Ng, 2006). The following section points out the quality attributes across a construction work lifecycle.

2.5 Quality Attributes in Construction Industry

The failure of construction projects can be minimized if quality is closely scrutinized and controlled throughout the design and construction stages (Lam and Ng, 2006). Quality has been a key issue in the UK construction industry since the late 1980s. This has improved the quality of the construction processes and the level of customer satisfaction (Pearce, 2006). Construction quality deals with both: a) service (as received by the client), and b) product (as received be the end-user) aspects of the construction project as well as the corporate quality culture (Arditi *et al.*, 2002).

The attributes of quality systems is divided into corporate-level and project-level, Table 2-6. This is mainly because the concept of total quality requires organisations to establish a well-structured and explicit system that identifies, documents, co-ordinates and maintains all the key quality-related activities throughout all relevant company and site operations (Pheng & Toe, 2004). This system is referred to as Total Quality Management (TQM). TQM drivers and mechanisms are explained in Chapter Four.

Table 2-6: Quality across a construction lifecycle

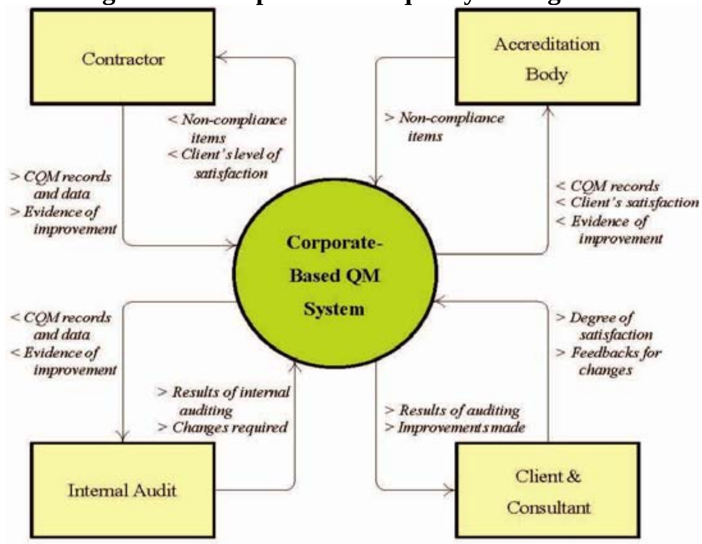
Construction Quality		
Project –Level (Quality Plans, Quality Assurance, Quality Control)		**Corporate-Level** (Total Quality Management Systems)
Product Constructed Facility (Received by End user)	**Service** Contract Planning (Received by Owner)	**Culture** Quality Systems (Received by Clients/Society)
Product Dimensions • Performance • Features • Aesthetics • Reliability • Durability • Conformance • Serviceability • Perceived Quality	**Service Dimensions** • Time • Timeliness • Completeness • Courtesy • Consistency • Accessibility • Accuracy • Responsiveness	**Quality Culture Dimensions** • Leadership • Employee empowerment • Partnership development • Information and analysis • Continuous improvement • Client focus

Quality performance in construction is results-oriented, and seeks evidence of quality awareness within the operations and outputs of contractors (Arditi *et al.*, 2002). Quality performance improvements are expected to increase the productivity and profitability of contractors, as well as increasing client satisfaction (Kibert, 2008). Unlike the mentioned environmental principles, the traditional view of 'quality versus productivity' has changed to 'quality improvement leads to improved productivity' in construction as well as in other industries (Green *et al.*, 2007). Therefore, construction quality is defined at: (a) a corporate level (where corporate strategies concerning how to perform the construction operation are formulated) and (b) a project level (where the construction systems produce a physical facility and provide a contracting service) (Arditi *et al.*, 2002).

2.5.1 Corporate-level quality

Corporate-level quality refers to the quality expected from a construction company in addition to the product and/or service quality. Pheng and Teo (2004) argue that construction quality is solely a restructuring and cultural change related process. The corporate-level quality in a construction company is experienced through the corporate quality culture. Curkovic and Sroufe (2007) depended on this level only for building an organisational Total Quality Environmental Management cost assessment. Nevertheless, some construction organisations treat quality as a routine exercise and pay little attention to the organisation levels. As a result, the expected improvement in quality at corporate level has not been truly realized (Lam and Ng, 2006). In figure2-3, Lam (2006) exemplifies the basic interactions between different parties involved in a construction work process and quality systems.

Figure 2-3: Corporate-level quality management



(Source: Lam and Ng, 2006).

The preceding version of ISO9000 (1994 edition) employed a process-driven approach whereby organisations have to demonstrate compliance to the procedures set out in their quality manual, but the common corporate quality records are only restricted to the organisation concerned primarily for self-monitoring and third-party auditing purposes (Arditi *et al.*, 2006). The alternative approach of Lam and Ng (2006) is to divide this level responsibility between various involved stakeholders. Figure 2-3 portrays Lam and Ng's (2006) conceptual Quality Management (QM) system which was build to provide contractors, clients, and external and internal audits with the quality data related to ISO 9001:2000.

The corporate quality culture in this level is the organisational value system that encourages a quality-conscious work environment. It establishes and promotes quality and continuous improvement through values, traditions and procedures (Arditi *et al.*, 2002). Arditi (2002) discussed the different variables related to corporate quality: leadership, employee empowerment, partnership development, information and analysis, continuous improvement, and client focus (Table 2-3). In this context, corporate-level quality aims to achieve client satisfaction as well as sustaining competitive advantage by delivering higher quality service and producing higher quality facilities (Ofori *et al.*, 2002).

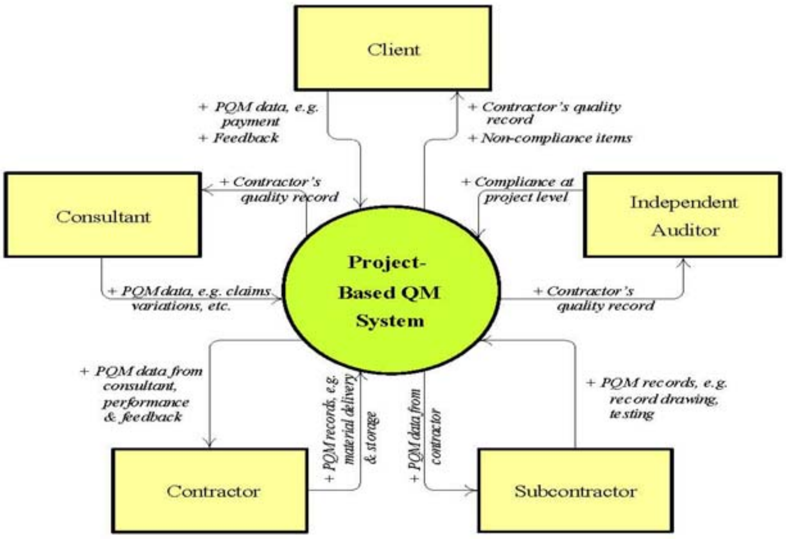
2.5.2 Project-level quality

Project-level quality can be examined in the following six areas: (i) briefing by the client, (ii) the design process, (iii) materials and component selection, (iv) project assembly on site (construction), (v) project management activities, and (vi) systems to promote project quality (Arditi *et al.*, 2002). The quality-related decisions of the client have to be made prior to the start of construction, because they set the tone for the type and function of the construction.

Project-level quality requires getting the quality right from the start of the project (Green *et al.*, 2007). This emphasises the importance of design quality which is the responsibility of the design team whether it be an independent consultant, in-house design group within the contractor’s company or within the client's organisation (Greenwood, 2006). This distinguishes design quality from project quality as project-level quality is controlled by the main contractors. Hence, in D&B procurement strategy, the design quality and the project-level quality are under the main contractor responsibility. In this case, clients could check contractor’s compliance on a random or regular basis.

As can be seen in Table 2-3 and figure 2-4, project level quality appears to have different variables (contractor, subcontractors, accreditation body, independent audit, consultant and client) compared to corporate level variables (contractor, accreditation body, internal audit, consultant and client). Arditi, Yasamis and Mohammadi (2002) did not specify the project quality attributes related construction processes; therefore it may be more difficult to implement the operational quality compared to the corporate quality. In fact figure 2-4 looks very similar to figure 2-3 in terms of ignoring any link to the selected procurement route.

Figure 2-4: Project-level quality



(Source: Lam and Ng, 2006).

The literature in this area comprises different elements as collected in Figure 2-3. The corporate level appears to reflect the TQM vertical integration within a construction company. The horizontal integration throughout the supply chain of the construction industry or the project-level quality appears to be vague. This is because any link between project level quality and the selected procurement route has been ignored. Therefore, no justification can be found for not considering other possibly involved parties i.e. suppliers or type of contractor, such as main contractors or sub-contractors. This may be due to the construction projects' nature of uniqueness and complexity. Other conceptual quality and environmental management frameworks are discussed in Chapter Four. Due to the gap found in the literature, the current research aims to link TQM with environmental management and to develop a framework for Total Quality Environmental Management (TQEM) vertical and horizontal integration.

This section focuses on the recognition of the link between corporate and project level TQM within a principle contracting organisation. The prime objective of the corporate level is to develop contractors' aims, policies and objectives which drive the business (Watson and Griffith, 2004: 9). The authors presented the prime objective of the project level as delivering efficiently and effectively the company's projects on time, budget and high quality while making profit. This study suggests that TQEM in construction projects could similarly include a mix of product and service dimensions. On one hand, the service TQEM dimensions may be easily interpreted as they are directly associated with contracting services, but on the other hand, the product

TQEM dimensions are associated with the construction product, i.e. the constructed facility. The interrelationships between the design and the delivery of construction products and services impede defining quality dimensions in precise terms.

The elements of the project TQEM process of the design and construction systems are not always as visible to the end-users as they are to the contractors. To be able to define these elements in a construction project, contractors' perspectives need to be studied with regard to the corporate-level and project/product-level focus because the product level is mostly associated with the end-user, whereas the owner is the most direct recipient of all service TQEM processes. In some cases the owner and the end-user are the same entity. When they are not, the product and service quality dimensions reflect the perceptions of the party that most directly experiences the product or the service associated with the construction process. Therefore, it is important to link these levels to the different parties involved in construction project and the procurement systems that divide the responsibilities between them. The different parties participating in a construction work processes are highlighted in the following section.

2.6 Stakeholders across a Construction Project

Project stakeholders are individuals or organisations who are actively involved in the project or whose interests may be positively or negatively affected as a result of the project (Watson *et al.*, 2008: 49). It is important to identify project stakeholders and determine their needs to deliver a successful project. Stakeholders include the project manager, client, contractor, consultant, subcontractors, end users and suppliers (Watson *et al.*, 2008: 46). Table 2-7 shows the points in time within the life-cycle (represented by the black dots) at which the various interested parties may conduct assessments or are interested in assessment results. Additionally, it illustrates which stages of the building life cycle are usually included within the interested parties' considerations directly (the continuous line) and also within a broader perspective that should be considered (the dashed lines).

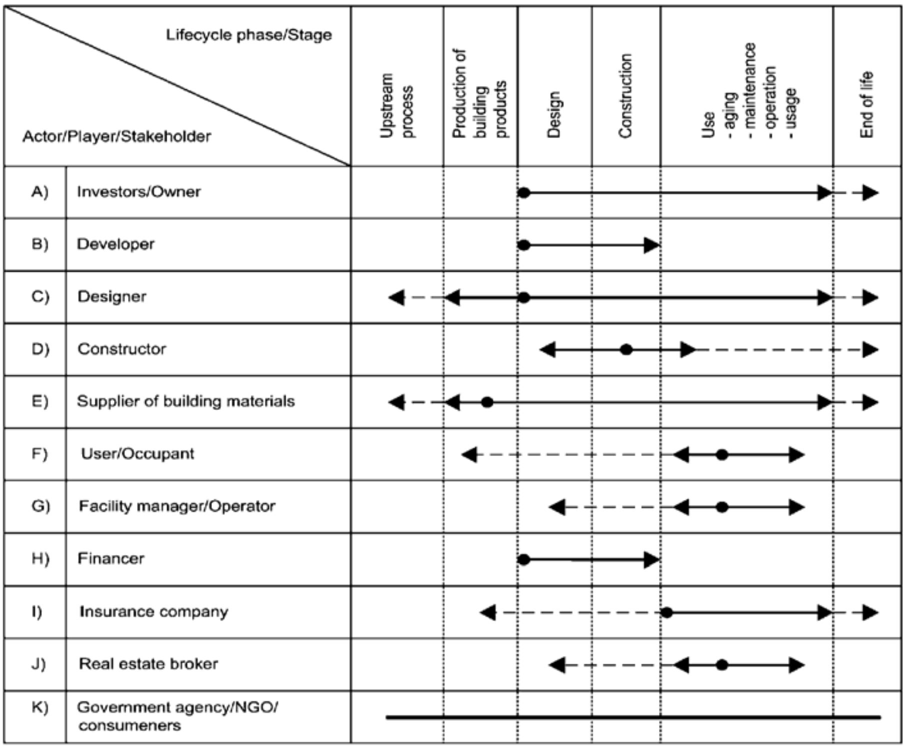
2.6.1 Major Clients

The term 'construction client' includes the owner (i.e. the agency or organisation funding the project) and the end user of the construction (i.e. the general public)

(Arditi *et al.*, 2002). The construction industry carries out work for a variety of clients ranging from small inexperienced clients who build frequently and understand the industry well. These clients are either from the public sector or private sector (Ashworth, 2008). Some of the key construction clients are water companies, British waterways, British Energy, Rail Track, the Highway Agency, port authorities, major retailers and house builders (Morledge *et al.*, 2006: 81). Most of the clients are inexperienced and irregular purchasers from the industry, however, most of the expenditure is generated by a small percentage of the experienced clients. Historically, the government has been the major client in the construction industry. This fact is shrinking due to the large number of departments being privatized (Ashworth, 2008; Morledge *et al.*, 2006).

This client domination might work to the favour of improving the construction performance if the client drives the change by aiming to commission projects of which present and future generations can be proud. Yet, the government is still an important player as it accounts for a large percentage of the construction industry output. 37% of the construction industry's turnover is funded by the public sector that consists of central government, local government and other bodies, funded either entirely by the government or in receipt of capital grants such as lottery grants (DTI, 2005: 240).

Table 2-7: Stakeholders across a construction work lifecycle



(Source: ISO/DIS 21931, 2008).

The UK government plays a major role in promoting change in the construction culture towards sustainability as a major client and regulator (Greenwood and Hamza, 2009). Many government bodies responsible for public works have begun to insist on an effective quality and environmental systems as prerequisite for tendering. Public utilities are doing the same thing. Private developers with major projects in planning will follow suit. The basis of competition for business will shift from 'price only' to a combination of price and quality (Pearce, 2006). Consequently, if a contractor does not want to be excluded from bidding for available work, he should wait no more in establishing quality and environmental systems in his organisation. Even if such external pressure is not felt by some contractors at the moment, they will be fighting a losing battle against their competitors who have enhanced their productivity through better quality and environmental management. The next section highlights the types of contractors.

2.6.2 Types of Contractors

Contractors have a major responsibility for environmental management on construction projects in order to minimise adverse impacts of the site itself, in its environment, and in the resulting facilities (Ofori *et al.*, 2002). This section points out the major contractors' role in the UK construction industry. The fragmentation of construction supply chain contributes to the industry complex industrial structure (Fellows *et al.*, 2002:5). Types of firms includes general contractors, who undertake a range of building and civil engineering work, specialist management consulting firms undertaking project management and consultants-architects, quantity surveyors and engineers (Ashworth, 2008).

There are contractor companies offering a combined design and built service and some offering a "one-step shop" to clients. Peripheral services, such as materials and component supply and plant hires, remain separate but are becoming more integrated into the industry's activities as the trend towards greater prefabrication leads to increasing off-site activities. This fragmentation of the supply chain contributes to complex industrial structure (Fellows *et al.*, 2002: 2).

Whilst there are more than 1896958 UK based VAT-registered construction companies in 2005. A distinguishing characteristic of the construction industry is its domination by a small number of very large companies (Barrett, 2008b). This should have had made developing the industry performance possibly easier. However, the vast size of the construction industry (107.01 billion in 2005) means that their individual market share is very low, amounting to a few percent of the market. The top 15 or so companies have less than 20% of the total market between them. For specific sectors of the industry, major players' market shares are more significant. The majority of these are companies that have an involvement in a wide range of projects, with particular strength in large infrastructure works. Some of these large companies are involved in house building including work through subsidiary companies (Keynote 2005:77 and Keynote 2006: 15).

Generally there are two broad types of large company: general construction companies such as AMEC, Costain, and Balfour Beatty with interests in several sectors. For example, infrastructure, commercial, industrial and support services and specialist companies, such as Barratt and Bellway in the housebuilding segment (Keynote, 2006: 39). The total value of the UK construction was 32.6 billion pounds in 2005. 20 companies (36% of the total) had a market capitalization in excess of one billion pounds and together accounted for 70% of the value in 2005. This was up from 5 companies (8%) in 2002. 32 companies (48%) were valued at less than 100 million pounds each in 2007 (Keynote, 2008).

Major contractors may have the capacity, recourses, skills required to champion improving the quality and environmental performance on one hand and to influence their suppliers and specialists subcontractors on the other hand. Major contractors influence has emerged from the domination characteristic, discussed previously in this chapter, with 20 companies together accounted for 70% of the value in 2005. The relationships between the different stockholders involved in a project are controlled by different procurement routes as explained in the following section.

2.7 Construction Procurement Systems

Construction procurement has attracted much attention amongst researchers. This has led to the profanations of many construction procurement systems in an attempt to find a way to reduce the time for building construction from inception to completion and to add value for money for clients. The adoption of quality systems has been mainly client-led (Curkuvic and Sroufe, 2007; Harrington *et al.*, 2008). However, there is a general movement towards making the implementation of a quality and environmental systems a contractual requirement (Arditi *et al.*, 2002; Greenwood and Hamza, 2009). Despite this proliferation of construction procurement systems in recent years, no standard definitions or classification approaches have become generally accepted (Morledge *et al.*, 2006:3).

Many definitions can be found for construction procurement (Masterman, 2002, Morledge *et al.*, 2006, Marsh, 2002; Naoum and Mustapha, 1995; Okland *et al.*, 2006; Griffith, 2002). According to the International Commission on Building (CIBW92), during its 1997 meeting, construction procurement is defined as a strategy to satisfy client's development and/or operational needs with respect to the provision of constructed facilities for a discrete life cycle. This sought to emphasise that the procurement strategy must cover all of the processes in which the client has an interest (Masterman, 2002). Masterman defined construction procurement as: "the organisational structure adopted by the client for the implementation, and at times the eventual operations of a project".

In order to classify the various methods of procurements available, researchers have adopted different methods based on the way in which the interaction between the construction and the design, and sometimes the funding operation, is managed

(Morledge *et al.*, 2006). According to Masterman, 2002, construction procurement can be classified as:

- Separated procurement systems – where the main elements of the project implementation process, i.e. the design and construction, are carried out by separate organisations. This category includes the Conventional or Traditional system.

- Integrated procurement route – where one organisation or contractor, usually but not exclusively, takes responsibility for the design and construction of the project. Examples are Design and Built, and Develop and Construct.

- Management oriented procurement systems – where the management of the project is carried out by an organisation working with the designer and other consultants to produce the design and manage the physical operations which are carried out by contractors. This category includes Management Contracting, and Construction Management.

- Discretionary systems – where the client lays down a framework for the overall administration of the project within which he/she has the discretion to use the most appropriate procurement system. Examples of this category include Partnering and the British Property Federation systems.

A brief description of the various systems under the different categories is presented bellow.

2.7.1 Separated Procurement Systems

The unique characteristic of this category is the separation of the responsibility for design of the project from that of its construction (Morledge *et al.*, 2006). The only procurement system in this category is the Traditional or the Conventional System.

In this method the client appoints a design team led by the architect who also undertakes the overall management of the project (Masterman, 2002). Other specialist design consultants are appointed as necessary and a quantity surveyor is appointed to advice on costs. The client organisation also appoints a contracting organisation to carry out the construction work under separate contract from the design team. Table

2-8 below illustrates the main advantages and disadvantages of traditional procurement.

This method separates the design from the construction process and it is sequential in nature as the client takes the scheme design to an advanced stage team before the appointment of the scheme design to an advanced stage with the design team before the appointment of the contractor (Morledge *et al.*, 2006). This situation can result in lack of teamwork, which is crucial if the success and benefits of a TQEM project are to be realised. It can be seen that traditional method of procurement does not readily facilitate the use of the TQEM methodology explained in the previous chapter. The main reason is the separation of the design and construction teams.

Table 2-8: Traditional Procurement pros and cons

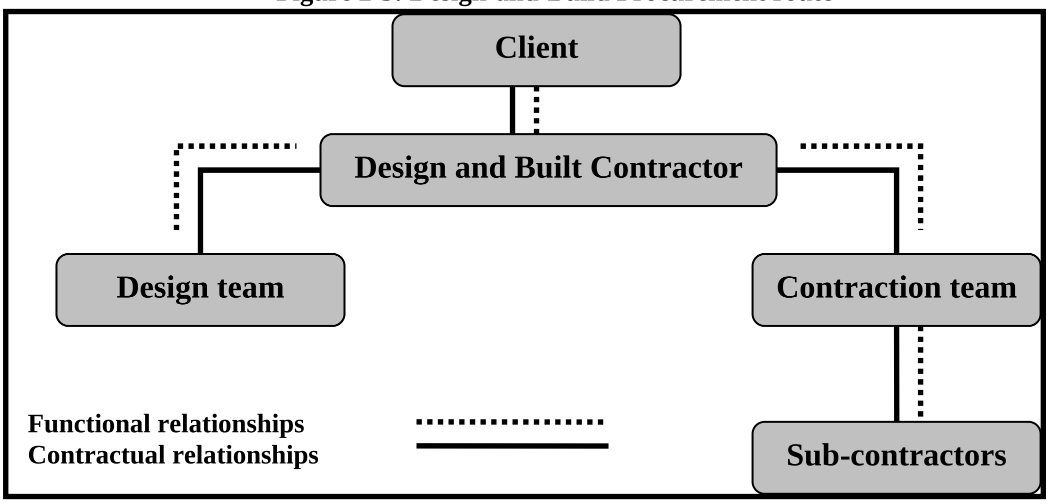
<table>
<tr><th colspan="2">Traditional Procurement Strategy</th></tr>
<tr><th>Advantages</th><th>Disadvantages</th></tr>
<tr><td>
• The system ensures lower costs for the client and proper competition if the design has been fully developed and uncertainties eliminated (Masterman, 2002).
• The existence of a priced bill of quantities enables interim valuation to be assessed easily variations to be quickly and accurately valued by means of prearranged rates (Masterman, 2002).
• It allows time and freedom for architects to develop designs fully (Morledge et al., 2006)
• It provides a higher degree of certainty that quality and functional standards will be met then when using other systems (Love et al., 2000).
• This system is well established and well understood by architects, contractors, subcontractors and clients (Morledge et al., 2006; Masterman, 2002; Love et al., 2000).
• The design team retains control of the way the design intentions are realised. Although it is the contractor who manages the actual construction process, his/her activities are subject to instructions from the client normally acting through the architect (Masterman, 2002).
</td><td>
• The tendering process is complex and expensive, and where too many constructors are allowed to bid the total costs involved can be very high (Walker and Hampson, 2003).
• The contractor has no input into the design or initial estimating procedure; the contractor's knowledge of his own methods of working, the skills available and the current market conditions of materials (Love et al., 2000). In this sense the contractor seems to be in a better position than the architect to judge some aspects of the buildability of a design.
According top Sustainable Procurement Report, 2006;
• The sequential and confrontational nature of this system can result in lengthy design and construction periods, poor communication between client and project team members and problems with buildability;
• While the facility to respond to late demands for change by introducing variations can result in satisfied customers, such actions have been identified as one of the main causes of delays, and increased cost. This can lead to a permissive attitude to design changes.
• Where tenders are obtained on the basis of incomplete designs, the bids obtained can only be considered as indicative of the final cost and the client is thus vulnerable to claims for additional financial reimbursement from the contractor.
</td></tr>
</table>

2.7.2 Integrated Procurement Systems

This category of procurement systems includes all the systems for which the management of the design and construction are integrated and become the responsibility of one organisation (Masterman, 2002). The main member of this group is Design-and-Build (also known as Design and Construct), but other variants of the design and built also exist.

The Design and Build procurement method has increased significantly over the recent years (Walker and Hampson, 2003; Morledge *et al.*, 2006). The design and construct procurement method can be defined as an approach that provides for an organisation to be contracted by a client to manage the design and construction processes (Walker and Hampson, 2003). The practicality of construction planning can be improved dramatically through practicing constructability principles. Table 2-9 below summarises Design-and-Build's key advantages and disadvantages. The factors presented in the table contribute to the reduction of the UK construction time for design and construct compared with traditionally procured projects. Therefore, the Design and Build procurement route offers a greater potential for the implementation of TQEM due to the integration of both the design and construction teams and the contractor's control over construction business and operations.

Figure 2-5: Design-and-Build Procurement route



(Source: Masterman, 2002)

Table 2-9: Design-and-Build Procurement pros and cons

Design-and-Build Procurement	
Advantages	**Disadvantages**
• The client has the advantages of dealing with one organisation that is responsible for all aspects of the project. • Provided that the clients' requirements are specified, certainty of final project cost can be achieved, and this cost is usually less than when other types of procurement systems are being used. • This system results in improving communication being established between the client and the contractor, and thus enabling shorter, overall projects to be achieved and project management efficiency to be improved. • Incorporation of design process into the construction program-integration of design and construction buildability. • Speed of response to alterations – design changes can often be more smoothly accommodated. • Pre-contract planning is more detailed; • Motivational benefit from the design and construction teams being on the same side. • Fewer reasons for extensions of time. • Better rationalization of design detailing. • Better and "right" solution prior to activity on site minimizing abortive work. • Short cuts available to designer/builder – less parties involved in design.	• Difficulties could be experienced in evaluating proposals if the client brief is ambiguous. • Although well-designed buildings can be obtained when using this system, the client has very little control over the project as compared to other procurement systems.

(Source: Walker and Hampson, 2003)

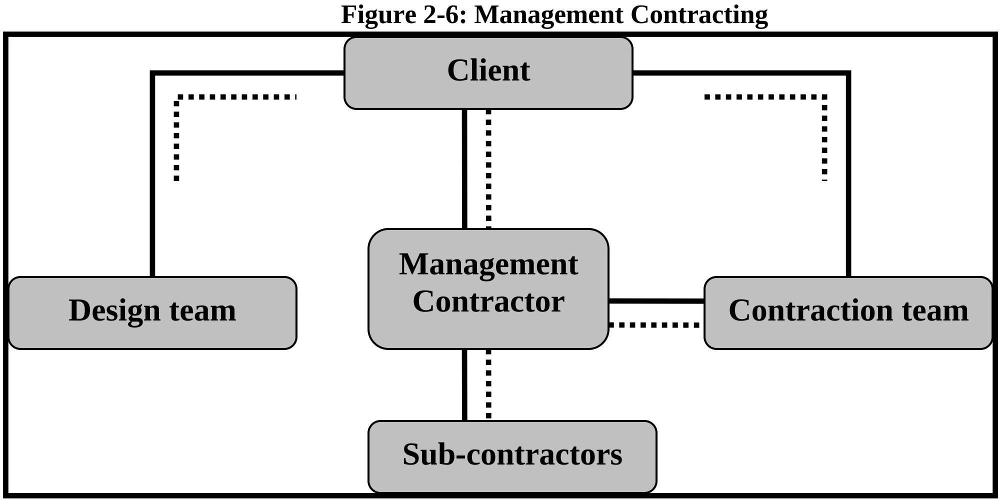
2.7.3 Management-Oriented Procurement Systems

This category includes two systems of procurement which are usually treated as 'non-traditional' but which are really developments of the traditional system, in that they are designer-led. These include managing contracting and construction management, systems in which the contractor is elevated to the status of a consultant and special emphasis is placed in the integration to the management of both design and construction (Masterman, 2002). Thus they are also sometimes referred to as fast-track methods because by allowing the design and construction stages to overlap, actual building work can be started earlier than under the traditional procurement system. These systems are mainly used by large organisations such as the big retail chains which have major construction programmes and considerable experience (Morledge *et al.*, 2006).

a) Management contracting

This system involves the addition of management contractors to the client's professional team. As can be seen in Figure 2-6, the management contractors employ the trade contractors who carry out the actual work (Masterman, 2002). This management contractor has an increased involvement in the decision making process thus improving the management input. The client has much greater control of the project and also the method allows for overlap of design and construction.

Figure 2-6: Management Contracting

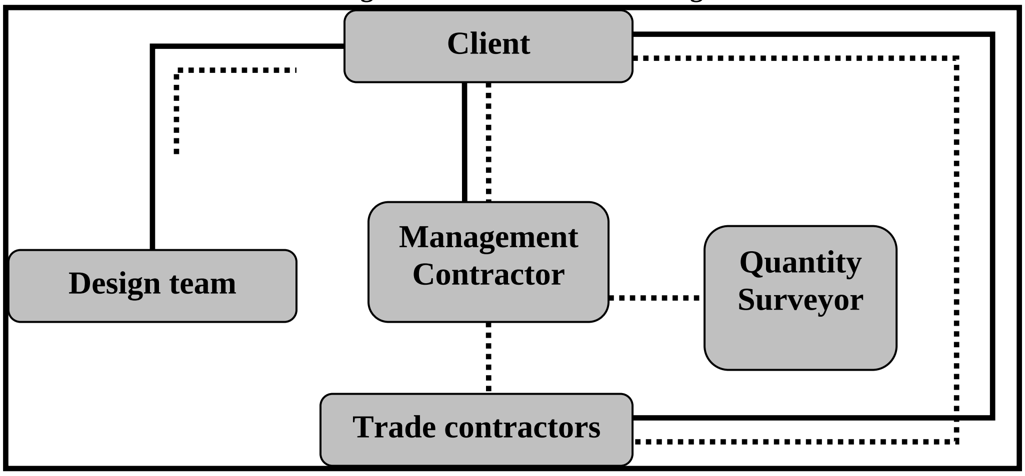


(Source: Masterman, 2002)

b) Construction management

In this method the client employs trade contractors directly. The construction manager is appointed very early in the process and is of equal status to the other consultants (Masterman, 2002). The contractor here holds very little risk as the majority is born by the client (Figure: 2-7).

Figure 2-7: Construction management



(Source: Masterman, 2002)

While design and construct allows consideration of constructability during the design process it should not, however, be confused with a fast-track approach to management of the design and construction phases of a project (Naoum and Mustapha, 1995). Fast-tracking attempts to accelerate the whole period of design and construction of projects by simply overlapping design and construction phases. The main problem associated with the implementation of this technique is that mistakes made during the early design/construction phase may have far-reaching effects on construction time delays (Morledge *et al.*, 2006). The advantages and disadvantages from the management-oriented procurement systems are highlighted in Table 2-10 below.

Table 2-10: Management-oriented procurement

Management-oriented procurement	
Advantages	**Disadvantages**
• These category procurement systems have a high degree of flexibility to allow for delays, variations and rescheduling of works packages. • This system enables the commencement of the project to be accelerated, which in turn, should enables earlier completion to be achieved then the separated procurement systems. • Early advice can be obtained from the contractor/manager on design, buildability, programming, and materials availability, together with general construction expertise (Morledge *et al.*, 2006).	• The issue of maintaining quality control through this category system is problematic. The client may therefore need to appoint additional site supervision to avoid difficulties in determining the responsibilities for defects and to ensure that the specified quality and environmental standards are achieved. • Although the contractor/manager is responsible for supervising construction and ensuring that work is built to the standard identified by the design team, the fact that his obligations are limited to his management performance implies that the client is liable for the cost of remedying any defects resulting from the substandard performance of any works contractor who is unwilling or unable to rectify his own faults. • The client bears a major part of the risk involved and can be particularly burdensome where works package contractors fail to perform (Masterman, 2002).

Management oriented procurement systems are very much client oriented. In addition teamwork is an inherent characteristic of the system. Although, the system maintains separate design team, there is the advantage of inputs from the contractor. Thus, this system also could lend itself to the implementation of TQEM with more difficulties than enhancing Design-and-Build due to the problems associated with maintaining quality and environmental control.

2.7.4 Discretionary Procurement Systems

The discretionary system of procurement is an administrative and cultural framework into which any procurement system(s) can be incorporated. Thus, allowing the client to carry out the project by imposing a very specific management style, or company culture, while at the same time enabling him to use the most suitable of all the available procurement systems (Masterman, 2002). This system includes the British Property Federation (BPF) and partnering.

a) British Property Federation (BPF)

This system was developed because members of the BPF have become increasingly concerned about problems in building which occur far too frequently, particularly those of poor design, inadequate supervision and insufficient choice of materials. Many contract methods cause delays, by their nature are inefficient and can substantially increase costs (British Property Federation, 1983). In this system the design team still provides the design function but their management role is curtailed. A client's representative and a design leader are appointed to take over this role.

b) Partnering

Partnering is a system which relies on trust and collaboration and has at its core a philosophy of real co-operation, partnership and equality among all the members of the project team, thus engendering a mutual desire to fulfil the projects objectives (Masterman, 2002). This is a means of administering and establishing and environment within which a project is implemented using any of the available procurement systems. Successful partnering can only be achieved if all the participating organisations are prepared to trust each other (Walker and Hampson, 2003). This trust could be achieved through the implementation of TQEM framework.

As can be seen in Table 2-11, comparisons between these systems are often made without reference to design quality. Nevertheless, regardless of the procurement system, the quality of design greatly influences the quality of the construction project. Since the quality of the output of any given process depends, to a large extent, on the inputs, it is of utmost importance that the inputs are as accurately determined as possible. If the client requirements are not properly analysed and understood, the project team could apply the best of procurement methods, but the output will be a product that does not conform to the actual specifications of the client. There is therefore a need for a management-based framework to aid the design and construction teams improving their performance.

Table 2-11: Comparison between construction procurement strategies

Characteristics	Traditional	Design-and-Build	Management contracting	Construction management
Diversity and responsibility	Moderate	Limited	Large	Large
Size of market from which costs can be tested	Moderate	Limited	Moderate	Large
Timing of cost certainty	Moderate	Early	Late	Late
Need for early precise definition of client requirements	No	Yes	No	No
Availability of independent assistance in development of design brief	Yes	No	Yes	Yes
Speed of mobilisation	Slow	Fast	Fast	Fast
Flexibility in implementing changes	Reasonable	Limited	Reasonable	Good
Availability of recognised standard documentation	Yes	Yes	Yes	No
Ability to develop proposals progressively with limited and progressive commitment	Reasonable	Limited	Reasonable	Good
Cost-monitoring provision	Good	Poor	Reasonable	Good
Construction expertise input to design	Moderate	Good	Moderate	Good
Management of design production programme	Good	Poor	Good	Good
Influence in selection of trade contractors	Limited	None	Good	Good
Provision for monitoring quality of construction materials and workmanship	Moderate	Moderate	Moderate	Good
Opportunity for contractors to exploit cash flow	Yes	Yes	Yes	No
Financial incentive for contractor to manage effectively	Strong	Strong	Weak	Minimal
Propensity for confrontation	Moderate	High	Moderate	Minimal

(Source: Code of Practice for Project Management- The Charted Institute of Building)

The 'traditional method' of procurement presupposes that designs are completed before contractor involvement. In contrast, D&B relies upon a certain amount of concurrency in design, procurement and construction. Data based on extensive survey support this, and indicate that together 'pure' (20%) and 'novated' (26%) Design-and-Build procurement, account for nearly half the value of proposed construction projects (RICS, 2007). The way in which benefits of a management-based approach like TQEM could occur is through better coordination of the design and construction phases of projects to allow an integrated approach to influence design details, particularly with reference to developing a more easily constructed design. The D&B procurement system may be the most suitable when considering the application of TQEM in the construction industry and is therefore be used in this thesis.

2.8 Novated Design-and-Build Principal Contractors

Research shows that there has been a continuous increase in the use of D&B over the last 15 years (Lindsey, 2003; Morledge *et al.*, 2006). Many clients regard it as providing value for money whilst contractors see it as an opportunity to apply their key strengths in management and coordination of design and construction works (Arshi and Gidado, 2004: 2). Hence, the performance of D&B contractors is subject to considerable variation dependent upon the main contractor technical and managerial competence (Masterman, 2002: 81).

Over the years, several different configurations of D&B procurement have evolved. Pain and Bennett (1988) stated that there are four principal ways of organising Design-and-Build. Akintoye (1994) identified six principal types while Andrews (1999) identified five different forms. Chevin (1993) states that there is evidence to suggest that these developments have caused some confusion amongst clients and have served as a drawback to the adaptation of D&B. Hence, D&B can be conceptualised as ranging from pure D&B to detailed-developed D&B.

- **Traditional Design-and-Build:** The contractor accepts total responsibility for both the design and construction to meet the requirement of the client.

- **Package deal:** The contractor provides standard buildings or system buildings that are adapted to suit clients' space and functional requirements.

- **Design and manage:** The contractor gets a fee for managing all aspects of planning and design and supervising the subcontractors. The contractor has design responsibility.

- **Design, manage and construct:** This is similar to 'design and manage' except that the contractor is involved in construction of some work sections in addition to coordinating the activities of the subcontractors on site.

- **Novation D&B:** The client passes his architect to contractor to produce detailed drawings as part of the contractor's team. During the design stage through to the appointment of the D&B contractor, the architect works directly for and is paid by the client. Once a contractor had been appointed the architect's appointment is assigned to the contractor for whom the architect produces any outstanding information, which is necessary to construct the work.

- **Develop and construct:** This is a hybrid of D&B in which the contractor inherits the design that might have been produced by client's consultants. This is developed further by the contractor in terms of detailing taking into account the construction technique to be adopted for the project. It is different from Novation D&B in the sense that the architect that provides the concept design is not passed to the contractor by the client.

These categories are distinguished based on the level of pre-contract design and specification issues. Out of these possibilities, Novated D&B is selected for application to this research. Masterman (2002:81) argued that this system contains three fundamental elements: 1) the responsibility for design and construction lies with one organisation, 2) reimbursement is generally by means of a fixed price lump sum, and 3) the project is designed and built specifically to meet the needs of the client. Such an arrangement should enable the design of the project to proceed more smoothly from the pre-contract to the post-contract stage (Lindsey, 2003).

Novated D&B attributes depend on whose perspective they are viewed from, hence the main advantages are: i) the single point responsibility and control of the main contractor means that the client has to deal with one single organisation that is responsible for all aspects of the project, ii) certainty of final project cost could be achieved, and this cost is usually less than when using other types of procurement systems, iii) it enables design and construction to be overlapped, shortening the overall project period and leading to improved project management efficiency (Morledge *et al.*, 2006). A growing body of opinion contends that novated design-and-build is suitable for the implementation of most types of building, provided that the client's requirements are accurately specified (Lindsay, 2003; Arshi and Gidado, 2004, Abrahams, 2003).

Novated D&B is a popular procurement strategy where the client employs a design consultant, who is then novated to the contractors following their appointment. This route's popularity is recognized for its capability to deliver real value to both public- and private-sector clients. Thus, it appears to result in the worst outcome in terms of meeting clients' quality and environmental requirements. This situation of high adoption and poor quality and environmental performance led this research to develop a management-based performance improvement from the novated D&B principal contractors' perspective.

2.8.1 Main Problems

Recent research indicates that D&B contractors may lack proper understanding of managing the varying types of design processes, especially in the areas of environment and sustainability. This section presents novated D&B problems and establishes the need for management-based performance improvement.

Among the uncertainties which can disrupt novated D&B contractors are:

- the short-cut design process impact on quality and environmental performance
- cost estimation and competitive tendering,
- decreased accountability by the D&B main contractor, and
- correction of work.

The short-cut design process impact on environment and quality performance: The short-cut design process may restrict regulatory review efforts to a potentially cursory overview (Greenwood and Hamza, 2009). Projects may be designed as they are built, thus providing those with the responsibility of oversight little to no time at all to review completed plans and specifications. Projects completed before they may be reviewed can be forced into costly change orders to bring the project into compliance with regulatory requirements (Lavender, 1996: 260). Since the purpose of the design documents is to describe the project's desired outcome, an abbreviated design process can result in leaving out some details of the quality, workmanship, and/or desired aesthetic attributes of the project, thus making it impossible to hold the builder accountable for the desired level of quality (Masterman, 2002: 80).

It is interesting to note that although most literature on building sustainability recommends the D&B procurement system (Sustainable Procurement Construction Task Group, 2007), the literature does not identify environment, quality, or functionality as benefits when using this method of procurement (Masterman, 2002: 80). This reflects the prevalent culture and attitude among some clients, and certainly some architects, that D&B is most suitable for uncomplicated projects, and the belief that the quality of the finished product when using this method is lower than the one achieved by other systems of procurement (Greenwood and Hamza, 2009).

Current experience does not support this viewpoint as many large, complex and prestigious projects have been, and are presently being, constructed using this method (CEEQAL, 2008). This may confirm the opinion of many that the risk of the client obtaining a crude design solution, or a substandard project, arises only if the client's brief is inadequate and the selection of the bidding contractors is not carried out correctly (Morledge *et al.*, 2006). Arshi and Gidado (2004) found that the system performs better in terms of quality on complex or innovative buildings than on simpler developments. Arshi and Gidado survey findings (2004) established that only 50% of projects using this method met the client's quality expectations, compared with 60% of conventionally procured projects.

Cost estimating and competitive tendering: For novated D&B projects, it is sometimes difficult to conduct accurate cost estimation because design documents are often preliminary and may change over the course of the project. As a result, design-build contracts are often written to allow for unexpected situations, and the price of the completed project may vary greatly from the original estimate (Masterman, 2002: 78). The uncertainty of the early estimate requires the owner to rely a great deal on the integrity, acumen, and competence of the design-builder. As the certainty of estimate decreases, the reputation of the D&B firm becomes more important. Estimates should be accurate and reasonably verifiable in order to minimize risk[*] (Arshi and Gidado, 2004).

Decreased accountability: the design-builder is given a great deal of control over the entire process of both how the project is configured, and how it is completed. With no third-party observer (such as an independent architect) to administer the process, the unscrupulous design-builder may sacrifice the quality of materials and even structural elements in order to pad his own profits at the expense of the owner (Lavender, 1996: 263). This emphasises the importance of contractors' reputation, culture and attitude aspects of their management system.

Correction of work: since the client may not have the expertise to evaluate the quality of portions of the work, they must trust the design-builder to properly design a facility that will meet their needs, and to execute the design properly, according to codes consistent with industry-standard specifications (Masterman, 2002: 79). Unless the builder agrees with the client's assessment of the situation, the client may have no means to insist on correction of work done improperly but to go to some form of formal dispute resolution such as litigation, or arbitration (Lavender, 1996: 264). In exchange for the ability to save money, the client assumes the risk and responsibility to review contract documents, such as plans, specifications, and agreements for services, and to hold the design-builder accountable to design and deliver a quality product (Lavender, 1996: 263). In contrast, under the typical design-bid-build or negotiated project delivery system the architect is in a better position to reject work not performed according to the standards he set forth in the plans and specifications.

[*]Contractors are selected to undertake construction projects and the price for their work established by competition. This competition serve to drive down prices as the way to select contractors is to invite competitive tenders from competent companies (Arditi *et al.*, 2002). The low contract prices established by competitors, clients are faced with extra cost during their projects even though they have not alerted their requirements in any significant way (Morledge *et al.*, 2006). Consequently, many potential clients actively avoid new construction work due to the hassle it involves.

Yet, there are more shared problems contractors face regardless the procurement route, such as:

Construction difficulties: Technical, managerial and construction problems often occur over the course of a project (Barrett, 2008a). If these affect the construction time, quality or cost, then liquidity will be affected, because short-term finance will be required for a long period (Lavender, 1996: 263). Which party bears the cost of this will depend on how risk is allocated in the contract (Morledge *et al.*, 2006).

Change in demand: Another consequence of a lengthy project period is that market conditions can change considerably. For example, a development started in boom conditions can be severely affected by a recession, in which the consequent reduction in demand will lead to reduced prices and rents. This not only means lower profit, but also slower cash flow, delays and extended requirements for short-term finance (Arditi *et al.*, 2002).

Inflation: Inflation represents a major problem for building contractors. Not only must they consider dealing with inflation effects in the valuation of fixed assets, work in progress, etc., but also must allow for inflation in any company price tenders. Inaccurate prediction of inflation may mean the contractor makes a lost instead of profit (Curkovic and Sroufe, 2007).

Changes in interest rate: Interest rates affect the cost of finance. Their precise effect depends on the amount borrowed and the length of time involved (Curkovic and Sroufe, 2007). Increases can have a severe affect on project success, or even threatening the survival of the company itself (Lavender, 1996: 263).

Gaining approval: Before a project can be implemented, lots of planning, prioritisation, and preparations are required, which includes negotiating for a planning permission. This can cause delays in the project start time (Lavender, 1996: 262).

A major question is how much information is required from the contractors for the clients to ensure that the bid is compliant under the discussed new environmental regulations. The more information the better for the contractor, yet clients are more frequently novating designs to contractors at later stages in the design process. Consequently contractors are left with very little scope in design work, poor construction quality, more means of risks, and responsibility for gaining building control permission. Yet requiring all the bidding contractors to submit detailed proposal increases the overall tender cost and time. This is where a two-stage process provides more benefits for considerable design development in the second stage with one contractor. All the aforementioned aspects may affect the quality, environmental and sustainable performance of contractors. The next section establishes the key drivers for improving novated D&B contractors' performance within a regulatory, procurement and intervention context.

2.8.2 Key Drivers for Performance Improvement

There are concerns that the industry is not performing to the best of its abilities. These concerns mainly focus on areas regarding construction quality, environmental performance, clients' satisfaction and the fragmentation of the construction procurement processes (Sustainable Procurement Construction Task Group, 2007). In 2007 the industry wasted over one billion pounds due to defects and rework (Sustainable Procurement Construction Task Group, 2007). Good construction management involves getting the construction sequence right so as to minimize delays from key building materials not being supplied on time or one part of the construction being completed late or out of sequence. It also requires a management approach for identifying, assessing and managing project risk from the outset; and value analysis to drive out waste, and inefficiency (Barrett, 2008b). Based on the overview of the UK construction industry presented in this chapter, the following section identifies the possible drivers for performance improvement. These possible key drivers are classified into regulatory context, procurement context and the problem of intervention.

2.8.2.1 Regulatory Context

As the built environment consumes 50% of the energy within the UK, the construction industry has a significant responsibility for designing and constructing buildings that contribute to human well-being with reduced energy consumption and carbon dioxide emission during the course of their use. Building regulations to reduce this environmental damage, by good design, date back to 1965 in the UK, in the form of prescriptive regulations. In 2002, the regulations were satisfied by increasing insulation thickness and limiting glazed areas on facades; a response that was considered by some to restrict innovation in architectural design, construction materials, building services and control systems (Greenwood, 2006). In response, in 2006, the government introduced performance-based calculations for building energy consumption.

The appeal of this performance-based approach is as much about introducing a management-based approach that overcomes problems of overly rigid rules and inflexible enforcement as it is about regulating for results (Greenwood and Hamza, 2009). The solution here may be in the development of frameworks for action, identifying sources of knowledge and tools to meet performance based regulations, while considering current availability of materials and labour skill. This means that the compliance with the new environmental regulation is extended from the design phase, to management, performance, and procurement. In this sense, indicators for compliance can be divided according to the stages of the project into (i) the design stage, (ii) as built, and (iii) as operated.

From the foregoing it should be evident that the new 2006 environmental regulation is radical and far-reaching in its effect. The current research is concerned with its effect on the procurement and managerial arrangements in the industry.

2.8.2.2 Procurement context

A number of recent reports have highlighted changes in the way buildings are being procured in the UK. According to the Consultants' Performance Indicator Report, Design-and-Build as a procurement route increased between the years 2002–2003 from 12% to 30% of contracts (by value) while traditional, 'lump sum with quantities' contracts decreased from 35% to 29% from 2002 to 2003. The RICS survey of building contracts in use during 2004 reported a decline in what could be described as 'traditional' methods, with Design-and-Build accounting for just over 40% of total workload value, and partnering agreements featuring much more heavily. Data based on a more extensive survey support this, and indicate that together 'pure' (20%) and 'novated' (26%) Design-and-Build procurement, account for nearly half the value of proposed construction projects. The main advantages of integrative procurement practice are the increasing use of collaborative working methods' stating that proponents of collaborative working point to the reduction in the costs of striking deals (Morledge *et al.*, 2006).

Removal of the traditional barriers of independent design and lump-sum tendering has enabled clients to involve contractors and their supply chains at a much earlier stage. An integrated management-based approach, such as TQEM, requires high level of control over all aspects of a project from design to commissioning. Contractors can feel justified in offering a guaranteed price ‘at risk’ with Design-and-Build strategy. This risk is offset by a corresponding contractual right, afforded to them by the D&B strategy, to TQEM projects. There is a need to develop a management framework that pictures the interaction between various parties involved in the realization of a project.

2.8.2.3 The Problem of Intervention

The most obvious problem with altering the new building regulations to bring about significant change is that environmental and sustainability principles should be linked to the procurement strategies (Watson *et al*., 2008: 152). This is because higher risk is involved in gaining building control approval under the traditional procurement systems as it is customary that the architect, on behalf of the client, is responsible for gaining building control approval (Morledge *et al.*, 2006: 64). In contrast, in D&B projects, the contractor is the single point of responsibility for delivering the project, including dealing with building control approval. Contractors identify compliance with regulations as a risk factor in projects, and this is accounted for in their bid prices.

Without the introduction of TQEM framework, under D&B arrangements, the construction work starts immediately on site before finalizing the design, based on staged building control approval. Hitherto, principal contractors have had the choice of employing the client’s M&E consultants, or their own, or to allocate the complete package to a specialist contractor under subcontract (Greenwood and Hamza, 2009). An attractive aspect of improving this practice is the potential for the TQEM contractor to be concurrently ‘value engineered’. However, if TQEM does not specify the construction detail or the output specification, there is a risk that the quality and environment features of the completed facility may be compromised. Careful attention to the output specification is essential to achieve the required outcome.

To sum up, there is a perception of a gap emerging from not joining up the construction cycle and the development process management-based approach for performance development, especially in the newer areas of interest such as the environment. All this is adding to complexity and increased D&B contractors frustrations for management-based solution for performance improvement (DCLG, 2007). In particular, the complexities encountering contractors in ensuring design phase and construction performance environmental compliance, together with the improving quality and customer satisfaction. These factors have a potentially massive impact on the timing and nature of the design; of contractor intervention; and of the contractual and working relationships of those involved. It was these considerations that prompted the current research.

2.9 Summary

The extent to which a contractor company controls or influences over design and construction work variables depends on the type of contract. This chapter has established D&B main contractors need for management-based solution for performance improvement in the areas of environment and sustainability. Three drivers for novated D&B main contractors to seek such a solution were explained (regulatory context, procurement context and the problem of intervention).

The UK construction industry shows a high level of segmentation and fragmentation at both managerial and operational levels. The UK construction is a large, complex, and diverse industry comprising many types and sizes of organisations and representative bodies. The construction industry has a unique structure with a very large number of relatively small companies and small number of relatively big companies carrying out the majority of its turnover. Construction projects are capital-intensive and are characterized by long, complex and interconnected processes of planning, design and execution.

The construction industry contributes extensively to the built environment. The demand to resolve its massively damaging environmental impact can not be separated from the need to improve the industry performance as both have impact on the UK economy wider performance. The spiralling demands for more environment and sustainability performance mirror the evolution of quality management within construction. A proactive approach of EM coincides with TQM. Yet, the most obvious problem with altering the new building regulations to bring about significant challenge is that environment and sustainability principles should be linked to the procurement.

The UK construction industry importance is reflected in developing various procurement routs. Research has shown that out of the variety of the procurement routes, there is a continuous increase in the use of Novated D&B over the last 15 years. D&B attributes depends on whose perspective it is viewed from. Many clients regard it as providing value for money while as contractors see it as an opportunity to apply their key strengths in management and coordination of design and construction works. It has been argued that D&B is more efficient. However, these comparisons are often made without reference to design quality and environmental features. This situation of high adoption and poor quality and environmental performance led this research to develop a management-based performance improvement from novated D&B principal contractors' perspective.

There was a general acceptance amongst researchers that D&B was the procurement arrangement most likely to be encountered. Novation (by the client to the contractor) of lead designers (i.e. architects) was taken for granted but the prospect was raised of novation of the client's M&E consultant (to the main contractor, or even to a specialist sub-contractor) in order to preserve continuity and responsibility for compliance with the new environmental building regulation, in the form of the as-built model. Two-stage tender approach is recommended as a management-based solution could become an integral part of the tendering documents.

The success of the D&B procurement route could be undermined by issues arising from the rigid professional cultures of individual participants within project workgroups. These have the potential to inhibit the achievement of the quality and environmental key espoused benefits for better D&B project outcomes. The new environmental regulations add significant responsibility on novated D&B main contractors for designing and constructing buildings that contribute to human well-being. In 2006, the government introduced performance based environmental regulations. The appeal of this performance-based approach is as much about introducing a management-based approach that overcomes problems of inflexible enforcement as it is about regulating for results. In this case, the solution may be in the development of frameworks for action, identifying sources of knowledge and tools to meet performance based regulations, while considering current availability of materials and labour skill.

This framework should picture the interaction between various parties involved in the realization of a project. There is a perception of a gap emerging from not joining up of the construction cycle with the management-based solutions for performance development, especially in the newer areas of interest such as the environment and sustainability. In novated D&B projects, the main contractor is the single point of responsibility for delivering the project, including dealing with building control approval. Contractors identify compliance with regulations as a risk factor in projects, and this is accounted for in their bid prices. Without the introduction of management-based framework, under D&B arrangements, the construction work starts immediately on site before finalizing the design, based on staged building control approval. Careful attention to the output specification is essential to achieve the required quality and environmental outcomes.

It is likely that the main pressures on D&B main contractors to support EM will come from public sector and major private sector clients procuring large projects. It is possible that having a management-based framework for environmental and quality performance improvement will be the deciding factor between contractors being considered for such projects and will form a part of the procurement strategy. Yet, any effective framework for construction performance improvement must be firmly located in present reality of the construction industry. It must also take full cognisance of broader national development priorities, which reflect societal values and aspiration. Next chapter involves in reviewing main performance improvement initiatives from the UK construction industry, international construction and the manufacturing sector.

CHAPTER THREE

PREVIOUS RESEARCH ON PERFORMANCE-IMPROVEMENT

CHAPTER THREE: PREVIOUS RESEARCH ON PERFORMANCE-IMPROVEMENT

3.1 Introduction

The term 'performance-improvement' may take different meanings depending on the context in which it is used. Performance, at a global level, represents the results of activities (Arditi *et al.*, 2002). Traditionally, it has measured effectiveness (doing the right things) and efficiency (doing things right) (Porter, 2008). Numerous dimensions of performance can be found, such as quality, productivity, profitability, safety, timeliness, growth, attendance, clients, satisfaction, environmental and sustainability etc (Green *et al.*, 2007; Pearce, 2006; Arditi *et al.*, 2002). The aims of presenting the key performance improvement initiatives from the UK construction industry, international construction industries and the manufacturing sector are to evaluate knowledge from previous research and to identify the key components of a successful framework for performance-improvement.

In general, the framework for performance improvement in any given context requires: (i) key mechanisms criteria (not a single measurement), (ii) a level of analysis (such as end-users, employees, etc.), (iii) a certain focus (kind of performance desired), (iv) a time frame (short or long range), and (v) a measurement system (quantitative versus qualitative, objective versus subjective) (Arditi *et al.*, 2002). In an attempt to capture the objectives, mechanisms and the suitable management approach to address the problems discussed in previous chapter, this chapter highlights previous experience in performance improvement from the UK construction sector, international construction, and the manufacturing sector.

The discussion in this section comprises a performance-improvement initiatives' prioritisation and effective and combined use of the various mechanisms to drive improvement from the UK construction industry, the international construction and manufacturing sectors perspective. The section argues that the key successful factors for building performance improvement framework are: compliance, leadership, review, awareness, capacity building and performance-monitoring and evaluation as fundamental criteria of reform initiatives. The discussion also proposes TQEM as a solution for key problems in the UK construction industry.

3.2 UK Construction Performance-Improvement Initiatives

Quality and environmental performance in construction is results-oriented, and seeks evidence of quality and environmental awareness within the project operations and the processes outputs of a contractor (Arditi *et al.*, 2002). The performance is defined over the long-term for its effects to be permanent characteristics (Curkuvic and Srouf, 2007). The discussion that follows comprises different performance improvement initiatives to select the appropriate objectives, mechanisms and management-tools.

3.2.1 Historical Context

The underachievement of the UK construction industry has occupied a place in several government reports and performance initiatives, and a level of improvement has been elusive. The industry continues to face substantial demands for improvements in productivity, efficiency, quality, cost control, contract disputes, and sustainability. Notwithstanding the huge challenges discussed in the previous chapter, numerous reform initiatives have been initiated to support the necessary development of the construction industry. While some of these have shown progress towards their objectives for reform others have reflected the industry's 'fire-fighting' approach instead of problem-solving, especially in the new areas of interest such as the environment and sustainability. Table 3-1illustrates some of these initiatives and the objectives set by each one.

Table 3-1: Performance-improvement initiatives

	Year	Key Objectives
Constructing the Team (Latham)	1994	The report proposed a clear action plan for improvement, asserting that implementation must begin with the client and made ten main recommendations including that the Government commit itself to becoming a good practice client.

Levene Efficiency Scrutiny	1995	Three main objectives; communicate better with contractors to reduce conflict and disputes; increase the training which their staff received in procurement and risk management; and establish a single contact point for the construction industry to resolve problems common to a number of departments.
Rethinking Construction (Egan)	1998	Egan five objectives are: Committed leadership; Customer focus; Integrated teams; Quality driven agenda; and Commitment to people.
Accelerating Change Report	2002	Three objectives: client leadership; integrated supply teams; and people issues.
Achieving Excellence strategic targets: building on Success conference	2003	Two strategic objectives: improve the cost and time predictability and quality of construction projects; and reduce average timescales for procurement.
Achieving Whole Life Value in Infrastructure and Buildings (BRE)	2004	Integrating the whole life value the environmental management technique in construction planning.
BREEAM	2004	Focuses on the following areas: Management, Health and safety, Energy, Transport, Water, Material and Waste, Land use and Ecology and Pollution.
CEEQUAL	2008	This award aims to give public recognition for civil engineering projects with high environmental performance.
The sustainable development strategy for civil engineering	2007	The strategy aims to provide an action for all organisations in the civil engineering supply chain. It comprises the following points: o improve management of impacts and resource o productivity, including whole life-cycle assessments o engage the supply chain at the earliest possible stages o of a project to ensure sustainable development principles are embedded o promote the business case for sustainable development to clients and financial institutions
Code of Sustainable Homes	2008	This voluntary approach has six levels of compliance: Level 1 – Above Building Regulations (10%) Level 2 – Intermediate (18%) Level 3 – 'Equivalent' to EST Best Practice / Ecohomes

		'Very good' (25%) Level 4 – Intermediate (44%) Level 5 – Zero carbon [Part L energy use] (100%) Level 6 – Zero carbon for all home energy use (145%) It sets minimum standards for six key issues of: Energy, CO2, Water, Surface Water Management, Waste, and Materials.

As can be seen in Table 3-1, *Constructing the Team* (Latham Report, 1994) recommended more standardized construction contracts, better guidance on best practice and legislative changes to simplify dispute resolution. Many of the legislative changes were made through the Housing Grants, Construction, and Regeneration Act 1996. The report considered that efficiency savings of 30% in construction costs over five years were achievable. The Latham report provides important critique of the industry identifies problems and redefines the market skills required of contractors and designers, yet there was no indication or guidance on improving the construction industry quality and environmental performance.

In comparison to the Latham report, the Levene Efficiency Scrutiny (1995) focused on improving the structure and management of construction projects, including more realistic budgets and timetables, and the skill level of contractors. As many of the government reports, this report was criticised for 'talking too much' rather than taking decisive action, while clients were identified as leaders in driving change.

Some of Egan's "drivers" and targets in *Rethinking Construction* (Egan Report, 1998) are essential to secure improvement in relation to the industry quality, environmental and sustainability performance. This government-initiated report is similar to the *Constructing the Team* report, hence it extended its predecessor's potential impact for efficiency savings through directly adopting manufacturing techniques. Setting optimistic targets for industry productivity improvements and for the reduction of waste and defects, the report led to the formation of different bodies to implement its initiatives (Griffith *et al*.., 2003). The sequential nature of the construction process was highlighted as a barrier to utilising the skills and knowledge of suppliers and constructors. This was followed by several Construction Task Force reports that provided a number of detailed recommendations aimed at the industry as a whole, and established quantified targets and measures for improvement (i.e. environmental key performance-indicators and the defects key performance-indicators: Keynote 2006).

The Egan Report itself did not escape criticism. Many practitioners claimed that it heightened perception that projects could be built more cheaply than was actually possible. In response, the ‘Achieving Excellence in Construction’ initiative (1999) was developed to set out an action plan and targets for implementation and achievement of the Egan recommendations. The basic principles of Achieving Excellence require clients entering into collaborative relationships with their suppliers so that all parties work in an open and mutually-productive environment and to ensure the full involvement of an integrated supply-chain. These principles are consistent with those of both ‘Constructing the Team’ and ‘Rethinking Construction’. *Constructing Excellence* brought together various initiatives in a more streamlined approach to the delivery of industry reform, including good practice demonstration projects across England and Wales. Unlike the original *Rethinking Construction* report, *Accelerating Change* highlighted the need for radical improvements in construction sustainability and the responsibility of the entire industry for delivering this.

Modernizing Construction Report (NAO, 1999) differs slightly from the previous initiatives as it reports on how the procurement and delivery of construction projects can be modernised, with benefits for all the construction industry as well as clients. The report pointed out D&B as a strategy for more collaborative working methods and reduction in the costs of striking deals and more productivity and invalidation. However this comparison was made without reference to design quality and environmental features associated with this procurement strategy.

In response, the Office of Government Commerce introduced “the Gateway process” requiring major procurements including construction to be subject to review at certain key stages, such as agreeing the business need for a project, and before a contract is awarded, by a team sufficiently independent of the project. The purpose is to ensure that the project is justified and that the proposed procurement approach is likely to achieve value for money. The essential missing elements in the Gate Way are: project management, risk and value management, integrating the project team, procurement strategy, whole life costing, performance measurement, design quality, health and safety aspects and sustainability, together with pointers to more detailed sources of advice and guidance.

The *Accelerating Change Report* (2002) comes out of *Rethinking Construction* and the Strategic Forum for Construction to prioritise client leadership, integrated teams, and people issues. These areas are vital for delivering widespread quality improvement throughout construction processes. Although the Accelerating Change Report did not highlight the linkage between improving the industry quality performance and environmental performance, it provided a strategic approach with separate targets related to improving the quality and environmental performance. Yet, it does not provide a framework for action on how to achieve these over-reaching strategic targets.

Society, Sustainability and Civil Engineering (2002) is a more sustainable focused approach developed by the Construction Products Association. This sustainability strategy presented a pioneer for incorporation of sustainable development principles into the construction supply-chain.

The BRE whole life value analysis (2004) was accompanied with an action plan on the delivery of the 2002 sustainability strategy. The National Audit Office analysis over the previous reports of Latham, Levene and Egan has resulted in capturing the key factors for better construction performance (Figure 3-1). The need for better quality, environmental concerns (i.e. waste management), integration, customer focus and continuous improvement were highlighted. This makes the case for a management base strategy with environmental and quality focus towards sustainability in the UK construction sector.

The sustainable development strategy and action plan (2007) aimed to drive real improvements in the performance of the civil engineering sector by addressing key issues such as leadership, embedding the principles of sustainability, capacity building and creating a supportive policy framework. This strategy submits to the UK Government Sustainable Development Strategy (DEFRA, 2005) presented in Figure 3-1.The accompanying action plan is challenging and will not soon make a positive impact (Sir Neville Simms, cited in: Sustainable Development Strategy for Civil Engineering, 2007).

Code of Sustainable Homes (2008) maintains that the current environmental building regulation are far from sustainable practices because a typical semi-detached house, for example, constructed to building regulations, emits 23kg CO2/m2 per year, making a 25% cut without relying on renewable energy sources (BRE, 2008). Although the code has created more environmental concern across the industry and professionals, no further procurement guidance for implementation was provided.

To assess the likely environmental performance of buildings, BREEAM was developed by the Building Research Establishment (BRE). Independent, certified assessors conduct assessments in several of the following categories: management, pollution, water, ecology, land use, materials, energy use, transport, health and well-being. The credits awarded in each area are weighted to produce a single overall score, on which the BRE awards a certificate for a BREEAM rating of 'Pass', 'Good', 'Very Good' or 'Excellent'. The assessment takes approximately one week, although the assessors may also provide consultancy advice during the design and specification stages of a project to increase the likelihood of achieving the desired BREEAM rating.

In this context, CEEQUAL (2008), the latest version of this Environmental Quality of Civil Engineering, encouraged the attainment of environmental excellence in civil engineering projects, and thus aimed to deliver improved environmental performance in project specification, design, and construction. CEEQUAL assesses performance in twelve areas of environmental concern, including the use of water, energy and land, ecology, landscape, archaeology, waste management, and community amenity. The assessment framework provides a checklist of appropriate actions for project teams to embed into their project's development. CEEQUAL provides a valuable motive and mechanism for delivering high level of environmental and quality standards. Further development of implementation framework was recommended for future research.

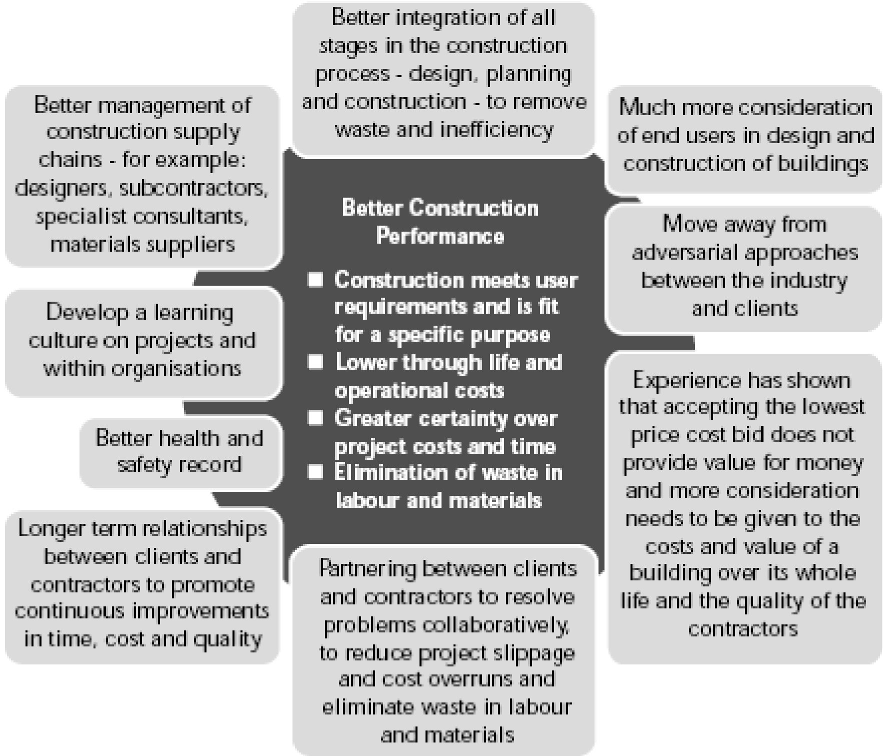
In summary, the quality performance of the construction industry has been a constant source of criticism and review for many years in the UK, while the environmental and sustainable performance has become a major concern more recently. This has culminated in a series of major initiatives aimed at changing the combative nature of the industry to one that effectively provides more value for clients and sustainable competitive advantages for contractors. There has been interest in specifying the issues, but little consensus on how to move forward. This thesis considers it vital for contractors to contact relevant bodies, including CEEQUAL, BREEAM, and BRE-whole life value, and actively become involved with them. This is seen as important for encouraging early interest in quality and environment performance improvement, and for developing and maintaining environmental leadership towards sustainability. The previously highlighted initiatives have made it possible to set out challenges for contractors and make clear proposals regarding progressive implementation of quality, environment, and sustainability issues drawing from various national experiences. Having presented major works outlining the historical development of construction performance-improvement initiatives, it is necessary to define the various construction performance-improvement objectives.

3.2.2 Objectives

Although it may be impossible to subsume all the previous initiatives into one strategy, there is a pressing need for clarity on shared aspirations, priorities, actions, milestones, and deliverables to move closer to achieving the growing concerns with sustainability (Green *et al.*, 2008). Existing research on construction management has not resolved the debate on how to improve construction performance towards sustainability (Harty *et al.*, 2007; Kibert, 2008). Objectives create the focus for any performance improvement programmes (Pearce, 2006), and are generally driven by high level goals and objectives (Hodgson and Milford, 2005). For example the Sustainable Strategy for civil engineering was established to promote sustainable development driven from the national objective of sustainability.

Clarity on priority reform objectives is most important to ensure focus, and is usually informed by policy, legislation and industry reviews. The objectives usually have to be cascaded out from higher-level objectives to more manageable lower-level objectives. For example, the Code of Sustainable Homes agenda set out an integrated framework of six levels of strategic compliance and six supporting actions to enable the construction organisations achieving best value for money from its construction procurement to assist the industry achieving its potential. Table 3-1 summarises the previous performance initiatives objectives. Although it is rather difficult to summarise all those objectives in one set, Figure 3-1 illustrates an attempt by the Gate Way initiative.

Figure 3-1: Targets for performance improvement for the UK construction industry



Source: National Audit Office Report (2002)

This research identifies the shared objectives among the presented initiatives as follows:

- management-based strategic approach for decision making
- improving quality and environmental performance
- management and workforce development
- continuous improvement towards sustainable construction
- innovation and recognition

It is very important to find suitable mechanisms to address these objectives. By comparing the previously-mentioned performance-improvement initiatives with peers from the overseas construction sectors, the following section briefly highlights the main lessons that could be learned from international perspective and suggests potential mechanisms to achieve these objectives.

3.3 International Construction Experience towards a Performance Improvement

International experience has shown that effecting change at a national or sector level is complicated, resource intensive, and can only be achieved over a relatively long period of time. Notwithstanding the huge challenges, numerous reform initiatives have been initiated around the world to support the necessary development of the construction industry – and many of these have shown progress towards their objectives for reform. An assessment of these reform initiatives (some of which themselves have been in existence for 10 years or longer) highlights key criteria for the success of such reform initiatives, and collectively these point towards a structured framework that can be adapted to national performance initiatives.

3.3.1 Background

The international reform initiatives reviewed by the researcher include, amongst others:

- assessing USA contractors quality performance (2002);
- The European Foundation for Quality Management Excellence Model (EFQM.EM);
- the Australian Construction (Industry Development Agency (CIDA) and the National Building and Construction Committee (NatBACC) Action Agenda - Building for Growth;
- the Australian Construction Policy (Steering Committee (CPSC)
- the initiatives of the Construction (Industry Development Board (CIDB) of Malaysia;
- the recently initiated Process and (System Innovation in Building and Construction (PSIB) programme in the Netherlands; together with a range of government and client driven initiatives aimed at furthering sustainable development, and in particular environmentally sustainable development.

- The performance improvement (programmes of the Building and Construction Authority (BCA) of Singapore.

It is beyond the scope of this paper to summarise these international reform initiatives, and the interested reader should make reference, for example, to the bibliography provided. The focus for improved performance in regard to quality and environment is located within the broader framework for performance improvement including the ethics, governance, procurement and delivery systems.

These strategies and action plans recognises the importance of common efforts, global action and collective responsibility for sustainable development, and for fulfilling the United Nations Millennium Development Goals (MDGs). In July 2006, Institution of Civil Engineering ICE signed a Protocol for Engineering a Sustainable Future for the Planet along with the American Society of Civil Engineers (ASCE) and the Canadian Society for Civil Engineering (CSCE). This articulated the organisations' continuing commitment to sustainable development and recognised that civil engineers have the knowledge and skills to play a major role in helping to meet the MDGs. The Protocol also committed each of the signatories to produce a sustainability action plan to help articulate and deliver more sustainable development. This document contains ICE's UK action plan for sustainable development.

An International Development Policy Group (IDPG) has been established to lead ICE's international development work and take responsibility for coordinating the international element of ICE's sustainable development strategy. ICE is also working to encourage other engineering institutions worldwide to sign up to the Protocol and produce their own sustainability action plans. The IDPG will build on the work of the ICE Presidential Commission 'Engineers without Frontiers' (EwF). The EwF Commission, which ran from 2003 to 2006, focused on the role of influencing, advocacy and partnerships in delivering effective infrastructure to help meet the challenge of achieving the MDGs. The Commission also produced a set of "Principles of Engineering for Development and Poverty Reduction" (EwF, 2005) to address the challenge of international development and set out the attributes required for successful development engineering projects to alleviate poverty.

3.3.2 Key mechanisms

In general, the framework for performance improvement, in any given context, requires; (i) key mechanisms criteria, (ii) a level of analysis, (iii) a certain focus, (iv) a time frame, and (v) a measurement system (Arditi *et al.*, 2002). The key mechanisms to drive performance improvement, learned from the performance improvement mentioned in the previous section, could be grouped under five headings; (a) compliance, (b) leadership, (c) review, (d) awareness creation, (e) capacity building and (f) performance monitoring.

3.3.2.1 Compliance

All performance improvement frameworks around the world are dependent to a greater or lesser degree on enforcement and compliance mechanisms. According to Hodgson and Milford (2005), these mechanisms vary significantly, and include:

- legislation to seek compliance with minimum acceptable standards (such as health and safety and certain environmental considerations)
- procurement instruments, which are one of the most powerful instruments used in all reform initiatives for effecting change amongst suppliers, specifying their requirements often requiring compliance with codes of conduct, standards, and guidelines, or the mandatory use of management systems
- registration and accreditation of contractors, designers, etc. according to specified criteria for different types of activities
- Commitment to voluntary compliance together with review mechanisms, to charters, codes of practice and/or conduct, management systems, reporting, including the numerous environmental and social responsibility charters such as the Equator Principles developed by leading international financiers and the FIDIC Integrity Management System, adopted by the World Bank and others.

3.3.2.2 Leadership

Another key to success is the type of leadership mechanism. Without exception, the role of leadership on individual and organizational levels has been fundamental to the success of every one of the more successful international initiatives (Hassan, 2006).

Common forms of leadership that are observed in the international reform initiatives include:

- Leadership by government demonstrating commitment and willingness to the construction reform initiatives. In the UK examples of such leadership by government include the procurement reform initiatives are being carried out in the Office of Government Commerce (OGC), the Better Public Buildings initiative in the UK and the Construction Client Charter and Demonstration Projects initiatives in the UK (Green *et al.*, 2007).

- Leadership by influential forward-thinking and progressive private sector organisations is relatively common internationally. Examples include those initial private sector clients participating on the UK Construction Client Charter, and members of influential organisations such as the World Business Council for Sustainable Development (WBCSD), Building Research Establishment (BRE).

3.3.2.3 Awareness creation

The third key successful factor is the development and dissemination of appropriate techniques and tools to support the attainment of the objectives. This can take various forms. Many systems were enforced through various instruments in many of the international initiatives, but the systems themselves provide a tool together with information to equip various stakeholders for change, as discussed by Hodgson and Milford (2005).

- codes, standards and guidelines, both voluntary and enforced through legislation,

- best practices, applicable to almost every reform initiative around the world,

- management systems, together with supporting implementation tools, specifying processes to be adopted and reported on, varying from full ISO 9001 and 14001 accreditation (which is currently required on selected projects in the UK), to the management systems developed to target specific issues – such as the NSW Australia OHS&R Management Systems and Environmental Management Systems,

- accreditation and rating systems together with supporting implementation tools, such as the LEED environmental design accreditation of design professionals in the USA, the NSW Contractor Best Practice Accreditation System, and accreditation systems for buildings – predominantly environmental and quality systems, and

- triple-bottom line reporting (schemes and methods, which are becoming increasingly common around the world.

3.3.2.4 Capacity building

Capacity building is a key successful component in several of initiatives around the world, according to Hassan (2006), including:

- formal training programmes for public(sector officials that support reform initiatives

- the establishment of public sector Centres of Excellence (such as the OGC Programme and Project Management Centres of Excellence in the UK), whose aim is to achieve significant improvement to central government capability to deliver successful programmes and projects

3.3.2.5 Performance monitoring

The last essential mechanism for the successful implementation of any strategy is performance monitoring, evaluation and review: Regular monitoring, evaluation and review is a key element of all international reform initiatives. According to Hodgson & Milford (2005), performance monitoring and evaluation takes place at both the "macro-level" and the "micro-level".

- At the "macro-level", for example, the UK has instituted the Construction Industry Indicators and the Quality of Life Indicators – setting high-level performance targets for the industry together with ongoing monitoring against these targets.

- At the "micro-level", the UK has initiated the OGC "Gateway" review process for acquisition programmes and procurement projects, and the CABE "Design

Review" for buildings that will have a significant impact on their environment, while Australia require closeout reviews of projects against certain criteria.

This section has pointed out the role of the construction industry in addressing the ways in which the industry could improve its contribution to sustainable development. Compared to international experiences, UK construction still has a lot to achieve to catch up with US and EU initiatives. The main lessons learned out of this discussion are the five highlighted mechanisms. These mechanisms could be enhanced for addressing the previously set objectives in a management-based framework setting. The following section seeks examples of integrated methodologies from the manufacturing sector.

3.4 Lessons to Learn from the Manufacturing Sector

While the UK construction industry continues to face substantial demands for improvement, the manufacturing industry, stimulated by the advances in technology and changing customer needs, have adopted new management based techniques and working practices, which have brought improvements in productivity and efficiency. Notable amongst the proposed management-based solutions was the concept of considering construction as a manufacturing process through the application of its management-based techniques.

The construction industry is presently at the point where the manufacturing industry was in 1980. However, the lessons and theories pertaining to manufacturing techniques can be applied to the construction industry in a rational and systematic fashion (Love *et al.*, 2000). As discussed in the beginning of this chapter, the Egan report was not the first to highlight the inefficiencies in the UK construction industry, and neither was it the first to suggest that the industry should take the manufacturing industry as a model for change. Egan (2004) vehemently rejects the claim that construction is in some special way different from the rest of the industry:

> *"We have repeatedly heard the claim that construction is different from manufacturing because every product is unique. We do not agree. Not only are many buildings, such as houses, essentially repeating products*

which can be continually improved but, more importantly, the process of construction is itself repeated in its essentials from project to project".

This section attempts to define the role and tasks of some popular manufacturing management methodologies in order to select a management based approach that addresses contractors problems discussed in Chapter Two.

3.4.1 Manufacturing methodologies and techniques in the construction industry

The following are some of the most popular management methodologies in the manufacturing sector. This section presents these management methodologies and their roles and potential tasks in performance-improvement towards sustainability process for construction industry.

Just In Time (JIT): JIT is a philosophy that defines the manner in which a production system should be managed (Hassan, 2006). Unlike other inventory control systems JIT attacks problems from the root. The essential objectives of JIT are:

- To eliminate waste. Waste in this context means anything that does not add value to a product (Pearce, 2006). Examples of the processes that do not add value to a product are: inspection, transportation, storage and setup (Hassan, 2006). Taking the case of inspection for example, the traditional approach is to strategy place inspectors to examine parts and if necessary fail them, this has a number of disadvantages, including the time it takes for the parts to go through the inspection process. JIT approach is to eliminate inspection by "making it right the first time" (Hassan, 2006).

- To strive for simplicity. JIT philosophy stresses on the desirability of simplicity on the grounds that simple approaches are most likely to lead to a more efficient management (Vais *et al.*, 2006). The primary thrust for sustainability covers two areas: Material flow, and Control. The simple approach to material flow aims to eliminate complex route paths by moving towards more direct, if possible unidirectional flow lines.

- To devise system to identify problems. Under JIT, any system which brings out problems is considered beneficial. One example is the use of statistical quality control to help identify the sources of problems (Hassan, 2006).

Unlike other inventory control philosophies, JIT is less expensive to implement. What is required is a reorientation of people towards their tasks. Thus any costs involved are mainly costs of training purposes.

Lean Manufacturing: Lean Manufacturing is an integrated set of principles and methods that enables companies to identify and eliminate waste from their processes, thereby dramatically increasing their competitiveness and profitability. It is commonly believed that lean started in Japan, but Henry Ford in the USA had been using parts of lean as early as 1920s (Kibert, 2008). One of the most noteworthy accomplishments in keeping the price of Ford products low is the gradual shortening of the production cycle. The longer an article is in the process of manufacture and the more it is moved about, the greater is its ultimate cost.

However, this approach development to the present state was by Taichi Ohno at the Toyota Automobile Company, which is the reason why Lean Manufacturing is also known as the Toyota Production System. According to Hassan (2006), the Lean principles are classified as:

- Value added. This is what the customer is prepared to pay for.

- Non-value Added. This is what the customer is not prepared to pay for, but is an integral part of the production process. An example is maintenance.

- Waste. This is what the customers will not pay for in the production processes i.e. transport, overproduction, inventory, motion, waiting, over processing, defects, and underutilised people.

In order to eliminate the mentioned waste types, Lean practitioners utilize many tools or 'Lean Building Blocks'. It is recognized that most of these may be implemented as stand-alone programs, because few may have significant impact when used alone i.e. Pull System, Kanban, Work Cells, Total Productive Maintenance, concurrent engineering, batch size reduction, workplace organisation, visual control and Total Quality Management (TQM) which is defined next.

Total Quality Management (TQM): Quality and total quality may be identified as two different concepts having a common ground or application. Quality is defined by ISO 8402 as the totality of characteristics of an entity that bear on its ability to satisfy stated needs or implied needs. This global definition, however, does not state clearly what constitutes the quality of systems (Vais *et al.*, 2006). In the case of building sustainability, quality is a dynamic state associated with the processes, environment and people. The main elements of quality, according to Hassan (2006) should include the following features: a) conformance to society specifications, b) conformance to legal and statuary requirements, c) meeting or exceeding the anticipated wishes of the society as a customer, d) superiority over competitors, and e) planning for sustainability.

Life Cycle Analysis (LCA): Life cycle assessment (LCA) is a method for evaluating the environmental impacts associated with the building from 'cradle to grave'. The LCA includes the entire life-cycle of the building from extraction of raw materials, processing of these raw materials, manufacturing of the product, transport, distribution, use, re-use, maintenance and refurbishment, recycling and final disposal. A building's life-cycle, according to Hassan (2006), includes the following five phases: 1.) Preceding phase: all activities outside the system: 2.) Construction: all activities up to the moment, 3.) Operation: energy used for heating, air conditioning, hot water, lighting, 4.) Maintenance and renovation, and 5.) Demolition. In this context, the LCA can yield a systematic analysis of the various building components, and processes resulting from the construction, maintenance and refurbishment of the building.

Life-Cycle Cost Analysis (LCCA): Life-cycle cost analysis (LCCA) is a method for assessing the total cost of facility ownership. It takes into account all costs of acquiring, owning, and disposing of a building or building system. LCCA is especially useful when project alternatives that fulfil the same performance requirements, but differ with respect to initial costs and operating costs, have to be compared in order to select the one that maximizes net savings. For example, LCCA will help determine whether the incorporation of a high-performance Heating, Ventilation and Air Conditioning (HVAC) or glazing system, which may increase initial cost but result in dramatically reduced operating (Hassan, 2006).

Value-focused thinking (VFT): Value-focused thinking is a well-established decision technique. This technique is suitable for the decision analysis concerning problems, which occurs frequently in the field of environmental and sustainable management of buildings (Vais *et al.*, 2006). The feasibility of applying the VFT, in this context, emanates from the fact that VFT provides an insight on different alternatives of building components and material so that the criteria of sustainable buildings can be taken into consideration (Hassan, 2006).

Agile Manufacturing: Agility is the ability to thrive and prosper in an environment of constant and unpredictable change. Agility is not only to accommodate change put relish the opportunities inherent within a turbulent environment (Green *et al.*, 2007). According to Goldman, Agility principles are: Delivering value to the customer; Master change; Mobilise resources; and forming virtual partnerships. Of these, the first three can be found within the operating philosophies of Lean Manufacturing. The fourth principle appears to be different. In fact, Agile and Lean take quite different attitudes towards partnerships and supply chain management (Green *et al.*, 2007).

Benchmarking: Benchmarking is a technique of comparing one of the processes in an organisation to a "best-in-class" example, either within or outside a construction company (Barrett, 2008b). Although, this technique is widely used in manufacturing companies that aspire to achieve excellence in their inputs and outputs, it is possible to harness this technique to serve the purpose of achieving sustainability in buildings (Hassan, 2006).

Value Management: As can be seen in Table 3-2, value management is a style management particularly dedicated to motivating people, developing skills and promoting synergies and innovation, with the aim of maximizing the overall performance of an organisation. It is a strategic approach to achieving maximum value in a project consist with the organisation's broad business goals (BRE, 2008) The structured team approach of value management to problem solving can be applied to the objectives setting, concept, design, and construction stages of the ongoing management of buildings (Green et al., 2007).

Table 3-2: Value Management

Value Management	
Principles	**Benefits**
• A continuous awareness of value for the organisation, establishing measures or estimates of value, monitoring and controlling them; • A focus on the objectives and targets before seeking solutions; • A focus on function, providing the key to maximize innovative and practical outcomes.	• Improved products and services to external customers by clearly understanding, and giving due priority to their real needs; • Enhanced competitiveness by facilitating technical and organisational innovation; • A common value culture; • Improved internal communication; • Simultaneously enhanced communication and efficiency by developing multidisciplinary and multitask teamwork.

Despite the differences between construction and manufacturing, highlighted in the section below, the Egan reports reject the idea that these should justify the industry's failure to adopt manufacturing management-based techniques. Yet, concepts like mass production, for example, might not be conceivable in construction itself. Some of the important generators of efficiency in the construction industry are common in other industries. For example, Love and Gunasekaran (2000) addressed the concept of concurrent engineering and its application in construction. In the same vein, the *Construction as a Manufacturing Process* report by the Innovation Manufacturing Initiatives (IMI), has led to the Generic Design and Construction Process Protocol (GDCPP) model (Lee *et al.*, 1999). Other techniques like lean, JIT and TQM have been implemented in the construction industry (Love *et al.*, 2000; Arditi, 2000).

Management improvement recipes, adapted from the manufacturing sector, such as value engineering, benchmarking, business process re-engineering and lean construction, demonstrate the same narrow fixation with instrumental rationality (Goodier *et al.*, 2007). They echo the oratory of Taylorism whilst propagating the supposedly neutral aims of 'improving efficiency' and "eliminating waste" (Goodier *et al.*, 2007). To overcome this criticism and the single management-based receipts limitations, a synergic approach may be obtained by integrating several methodologies to achieve performance improvement. The following section provides a few integrated schemes which were developed to support sustainability in the manufacturing sector.

3.4.2 Implementation of Integrated Schemes

Harnessing different methodologies by defining their common links and tasks and integrating them on different levels within the lifespan of buildings can increase the necessary competence for performance improvement towards sustainability (Hassan, 2006; Vais *et al.*, 2006). The following are a few examples of integrated schemes for performance improvement towards sustainability.

Integration of environmental management with corporate managements: Environmental management may be defined as a process that aims to balance socioeconomic, technological and ecological forces in resource allocation procedures, in order to achieve sustainable development and preserve the maximum evaluative potential of the biosphere (Hassan, 2006; Lawrence, 1998). Hence, the concept of Integrated Environmental Management (IEM) acknowledges the need to adopt a holistic view in the management of environmental systems, as opposed to the traditional sectoral approach that often results in the transfer of problems between different environmental components. On the other hand, an environmental management system may also be understood as a means of ensuring effective implementation of an environmental management plan or procedures and compliance with environmental policy objectives and targets (Welford, 2002).

Total quality environmental management: Total Quality Environmental Management (TQEM) is a methodology that combines environmental management and TQM. This general approach to organisational management emphasizes relying on only a few layers of management, employee suggestion plans, cross-function analysis teams, a systems approach, results-based measures of progress, and minimizing waste and consumption (Hassan, 2006). It intends to deliver continuous improvement, as explained in the following chapter. The standard components of TQM provide a solid basis for environmental management, and when combined with additional elements serve well to optimize environmental management.

The nature of Lean and JIT may make them suitable for the actual construction stage of a project, whilst Agile principles may enhance greater cooperation between project participants. However as illustrated by the previous chapters, the greatest saving could be made during the front-end activities such as client requirements processing. For supporting the integrated approaches, there are certification systems for EMS ISO 14001, which demonstrate that a system is operated to an internationally recognized standard (Hassan, 2006). By aligning TQM and EM, TQEM could provide a possible route to achieving the construction improvement objectives stated earlier in this chapter.

It seems that the reason for the slow uptake of the manufacturing techniques is the traditional concept of construction uniqueness. If the differences between construction and manufacturing industries are taken into consideration, the benefits of TQEM can be realised. The next section highlights the differences between the two industries that can affect the successful implementation.

3.4.3 Construction as a Manufacturing Process

This section aims to capture the differences between construction and manufacturing industries. It also points out the construction industry that may favour the implementation of TQEM. Building is an assembly process which, other than for a minor component of pre-fabrication, is carried out almost entirely on-site. The quality of the design can greatly influence the quality of the construction project. Since the quality of the output of any given process depends to large extent on the inputs, it is of utmost importance that the inputs are as accurate as possible. For a construction project, the inputs are the client's requirements.

The view that construction management can adopt management methodologies and techniques from the manufacturing sector are widely accepted (Egan, 1998; Green *et al.*, 2007; Pearce, 2006. Barrett, 2008b). This is mainly because in both manufacturing and construction work environments, the quality of work as received by customers is formed by: (i) the end product or service, (ii) all the transformation processes, and (iii) the input used to provide the final goods and services (Arditi *et al.*, 2002). Yet the distinction between the product, the services and the processes that transform resources into value are ambiguous in the construction industry (Barrett, 2008a; Arditi *et al.*, 2002; Green *et al.*, 2007). Table 3-3 captures some differences between the two industries which may affect the successful implementation of manufacturing management techniques.

Table 3-3, shows some characteristics of the construction industry which may favour the implementation of TQEM. For example, the active participation of the client in the construction process and the current move to more integrated forms of procurement like design and built, explained in chapter five, may provide a good groundwork for the success of TQEM implementation. Also the current move of some of the construction industry into entering strategic partnerships may encourage teamwork, which is critical for TQEM.

Table 3-3: Differences between Manufacturing and Construction

Manufacturing	**Construction**
Products are usually type production line type	Usually one-off
Product is usually simple in nature	Construction products are usually complex
Buyers of manufacturing are usually not deeply involved in the development process	The client of a construction product is deeply involved in the construction process
The produce generally tend to depreciate over time	The product appreciates in value over time
Product development involves the participation of permanent integrated departments in the same organisation	Temporary organisations formed on project to project basis

If the above differences are taken in consideration, the benefits of TQEM implementation can be realised. In both manufacturing and service work environments, the quality of work as received by a customer is formed by: (i) the end product or service, (ii) all the transformation processes, and (iii) the inputs used to provide the final goods and services (Arditi *et al.*, 2002). The active participation of the client in the construction process and the current move to more integrated forms of procurement such as D&B could provide a good groundwork for successful implementation of TQEM.

3.5 Possible Drivers for TQEM in UK Construction

The main problem, addressed in Chapter Two, is the situation of a high tendency to adopt D&B despite its poor quality and environmental performance. This situation has led this research project to develop a management-based performance improvement from novated D&B principal contractors' perspective. The demand for greater environmental and sustainable construction and increasingly stringent regulation also suggests that EM will become an important former feature, in the same way the quality management has evolved over the last thirty years (Watson and Griffith, 2004: 417).

TQM appears to be a popular approach for contractors. It enables focus on customer satisfaction, reduction in costs, sustained competitive advantages through (System, People, and Recourses) (Stephenson et. al, 2000). The construction industry is behind other industry sectors in adoption of EM concepts. EM is a management process that extends across the construction process through (requirements, responsibilities, and mechanisms) (Watson *et al.*, 2008).

There is no TQEM framework for UK contractors. This separation of TQM and EM functions could be counterproductive to effective resource allocation. The divide between corporate and project-levels within TQM and EM could make their interaction less effective. Independent EM and TQM in operation may lead to competitive demand for resources or priority attention (Stephenson *et al.*, 2000).

The recent concept of TQEM reflects the parallelism between quality and environmental problems. This could maximise the benefits, as TQEM focuses on organizational resources and improving customer satisfaction, and value, as TQEM is defined by the total costs that a product inflicts on society. The purpose of the next section is to establish the need for TQEM for improving D&B contractors' quality and environmental performance.

3.5.1 Reasons for TQM implementation in construction industry

Integrating TQM in the construction industry is a relatively new field, especially in the United Kingdom (Thorpe and Sumner, 2004). TQM could be a solution for cost reduction, increasing productivity, occupational safety and health and other problems construction industry is facing (Oakland and Marosszeky, 2006). Some researches have pointed out that by applying TQM better construction can be achieved (Green *et al.*, 2007). As suggested by Thorpe and Sumner (2004), if ever an industry needed to take up the concept of TQM it is the construction industry.

A study was conducted by Oakland and Marosszeky (2006) regarding the status of TQM implementations in construction industry. They found that the overall motivation for implementing TQM remained essentially the same over a period of three years, and that most firms believed that TQM is a good idea. The main benefits experienced are customer satisfaction, efficiency and effectiveness, productivity and reputation. The methods and effectiveness of implementing TQM, however, did vary substantially between companies over the three years. Some firms completely abandoned their TQM implementations while others achieved award-winning results.

In developing TQM culture in construction industry, one important step is to develop a construction team of a main contractor and subcontractors who would commit to the quality process and develop a true quality attitude (Arditi *et al.*, 2002). Thus, the main contractor should only select subcontractors who have demonstrated quality attitude and work performance on previous jobs (Pheng and Teo, 2004). Pheng and Teo, 2004, outlined the following steps for implementing TQM in construction projects: (1) Obtain the commitment of the client to quality; (2) general awareness and change attitudes of staff; (3) develop a process approach toward TQM; (4) prepare project quality plans for all levels of work; (5) institute continuous improvement; (6) promote staff participation and contribution using quality control programmes; and (7) review quality plans and measure performance. All these steps may have extensive contributions in boosting contractor quality performance. The same steps may be adapted to TQEM implementation.

3.5.2 Difficulties of implementing EM for Construction Industry

In the construction industry, those who see quality as simply a chore are on the fast track to going out of business (Thorpe and Sumner, 2004). Many client organisations now require formal evidence of quality management capability as condition for tendering for contracts or consideration for partnership projects. Client organisations are increasingly unwilling to accept poor quality and the consequent costs relating to rework and time overruns. This puts the pressure on the providers of goods and services to absorb the costs generated by their own shortcomings. The barriers to environment management in construction are classified in the following sections.

3.5.2.1 Different nature of the environment from cost, time and quality

The environment dimension has two fundamental differences from cost, time and quality (Vais *et al.*, 2006). On one hand, from the business viewpoint, the objectives of cost, time and quality are established on behalf of customers, but the objective of protecting the environment is imposed by the external bodies such as Environmental Protection Department, Labour Department, and Urban Services Department. On the other hand, from the viewpoint of economic development impact, cost, time and quality are micro-factors which influence the economy at the firm level in the short-term. The environment is a macro-factor which affects the firm and its development in the long-term targets. Such differences result from the fact that, although the seriousness of the environmental management problems from construction are appreciated by the public, government departments and construction professionals, the action of protecting the environment in construction works is still only enacted to a limited extent (Love *et al.*. ,2000; Pun *et al.*, 2002).

3.5.2.2 Less environment concern at the initial project stage

Few environment management activities are involved at the project planning and design stages. Some government departments apply the environment impact assessment approach, which is a method of assessing the total environmental impacts associated with a construction projects. Then constructed facilities and components are assessed as products in terms of their impacts relative to comparable products. Many construction projects have considerable environment risks which are not apparent at the early project stages but cause many potential pollution problems after the completion of projects (Love *et al.*, 2000).

3.5.2.3 Results-orientated policies

In general, environment regulations or policies usually respond to end products of the process, i.e. the pollutants. Less effort is used to identify pollution causes or study how to take a proactive approach in avoiding environmental problems such as air, noise and water pollution or land contamination and other environment responsibility (Arditi *et al.*, 2002). Many regulations can be found related to environment issues in a variety of forms i.e. Ordinances, Acts, or White Papers. Different guidance or legislation covers different aspects such as air and water pollution, waste, recycling, dangerous substances, health and safety. There is an urgent need, as the Accelerating Change report (2002) suggested to synthesize all environment regulations on construction into a coherent format that can be easily understood and implemented by all members of the construction industry.

3.5.2.4 Traditional culture and attitude

The management systems of cost, time and quality are widely applied in the construction industry. The need for environment concern has been traditionally viewed by construction professionals as an unnecessary burden in terms of time and cost. Such inadequate attitudes and behaviours are determined by many variables, for example, competitive economic environment, knowledge of environment protection, cost of environment management, sense of responsibility and degree of education received (Love *et al.*, 2000). Other factors include the attitudes of using the cheapest plant, labour, and method of construction driven by a competitive business (Yip and Joseph, 2000).

3.5.2.5 The cost of environmental management

The cost of environmental management is a new cost element for the implementation of environmental regulations. It includes the cost of facilities for protecting the environment, the cost of research on new methods or techniques for protecting the environment, and the cost of improving the damaged environment (Love *et al.*, 2000; Pun *et al.*, 2002). Nevertheless, a larger amount of environmental management expenditure will affect the company other expenditure such as payroll and reserves for future development, consequently affecting the business and the future of the industry (Yip and Joseph, 2002). This appears to be the reason why some countries have slowed down the pace of protecting the environment during construction booms. However, pollution has an irreversible effect on the environment. Further, if the expenditure on environment protection is less than adequate, the environment pollution rate will accelerate, and the expenditure on future remedial works will be greater.

3.5.2.6 Misunderstanding of environmental value

The environment value has been traditionally treated as approaching to zero prices. Kibert (2008: 5) points out: the natural environment has long been regarded as a cost. It has a zero-priced supply because no market place really exists for what it provides, except for a few desert areas, some refinements such as water purification or some coastal area storm protection schemes. The "zero-priced environment" concept has been widely applied in construction activities. Constructors can utilize the environment to the maximum degree without paying a price. The noise, dust and waste currently generated do not bring a cost to contractors but good facilities for preventing them will not bring any extra profit and may cost the business much more. Very often, the concept of "zero-priced environment" is applied to assess the economic performance for a place or a nation. Such assessment sometimes provides a superficial picture of prosperity. Environmental assessment can raise general green awareness and provide for a more informed and improved decision-making process. With improvement, it can also become a very significant element in the future of environmental protection.

This research argues that TQEM could provide a solution for theses barriers as the concepts of TQM could be readily applied to environmental issues, continuous improvement, customer focus and team approaches. Yet, management commitment is vital for understanding the value of applying TQEM to get to the rote cases of the environmental issues like waste and call for cross disciplinary teams to employ continuous improvement to implement ever cleaner solutions.

3.5.3 Novated D&B Principal Contractor's Responsibility

Novated D&B principal contractor's responsibility for the project quality and environment is highlighted in this section. Construction work can give rise to the environmental effects identified and which impinge heavily on workers' health and welfare (Watsoon and Griffith, 2004: 424). The principal contractor is generally bound by the Environmental Protection Act 1990 and also specifically by construction-related legislation: "The Construction Design and Management Regulations 1994 (CDM) require that health and safety is taken into account and managed throughout all stages of a project from conception, design and planning through to site work and subsequently maintenance and repair of the structure" (HSE, 1996a). Additionally, the Construction (Health, Safety and Welfare) Regulations 1996 dictate that all works must be "carried out in a safe manner and with due planning, organisation and supervision" (HSE, 1996b).

Successful environmental management and quality management of construction works is fundamentally for the three main reasons: regulatory, contractual and because of the intervention problem discussed in Chapter Two. It requires that the site works undertaken by the principal contractor are managed within an organisation of effective hazard identification, risk assessment, good supervision, and close control (Watson and Griffith, 2004: 425). Supervisors and managers must be cognisant of the dangers inherent to some operations and know fully what actions they need to take to mitigate risks and control the hazards threatened. According to Watson *et al.* (2000), environmental management throughout a construction project encompasses the consideration of environmental effects at regulatory, the company and project organisational levels. Watson, 2004, developed three key areas that make a prominent contribution:

- Environmental Impact Assessment (EIA). The environmental evaluation, undertaken by the client organisation during project evaluation and development, of the proposed construction project.

- Environmental Management Systems (EMS). The contribution made by the principle contractor to mitigating and managing the environmental effects of the construction project through the implementation of a formal company environmental management system.

- Environmental Management Plan (EMP). The translation of EMS into management procedures and working instructions for use on the site to ensure environmental control of site works.

Within novated D&B procurement strategy, TQEM assessment, related systems, and plans could be undertaken by the same contractual party (the principal contractor). This may add value to the whole project. Information from EIA will form part of the documentation which the principal contractor will use in tendering for the contract. Similarly, information from EMS/EMP will be fed back into the clients' project environmental file collected on completion of the project and used to provide information for future development projects.

Insuring that there is effective EM is no different from quality management functions (Watson and Griffith, 2004: 427). For effective EM it is necessary to compose a framework and structure which encapsulate the environmental ethos, policies and objectives of the principal contractor's corporate and project functions (Griffith, 2001: 338). It is also difficult for contractors to manage all these systems' documentation, as a result of the extremely onerous and bureaucratic documentation requirements (Lam and Ng, 2006). With the increasing the environmental regulation on contractors, if EM and TQM systems are not maintained effectively, contractors may find themselves being channelled into managing the documentation aspects of the certification process, rather than achieving the objectives of the improving quality and environmental performance (Oakland and Marosszeky, 2006).

There is a need to promote a quality and environmental culture, through better management based framework both within an organisation and among various stakeholders. A TQEM framework may help formalize and lead to a more effective TQM and EM process. Collaborative quality management environment may also eliminate duplicated efforts between quality and environmental systems. A TQEM framework could improve contractors' planning and control at a project level. If the corporate and project-related TQEM records are collated and dispatched to the client, suppliers, subcontractors through the help of management framework, improvement within a project quality and environmental performance could be achieved. This requires selecting elements from TQM and EM, as discussed in the next chapter.

3.6 Summary

The purposes of this chapter are to encapsulate the UK construction industry objectives, key mechanisms for performance improvement and the possible need for a TQEM framework. Discussion of the main initiatives for performance improvement in the UK construction industry has led to grouping the objectives. The objectives create the focus for any performance improvement model. The need for management-based strategic sustainable approach was highlighted. To improve the UK construction industry quality and environmental performance, it is important to address the spectres of climate change and the potential of civil engineering to contribute positively to the built environment.

The mechanisms involved in achieving these objectives are selected from the international construction perspective. A successful framework for performance improvement in the UK construction industry should combine various mechanisms to drive improvement. The key successful mechanisms for effective performance improvement initiative appear to be compliance, leadership, review, awareness and capacity-building as fundamental criteria of reform initiatives.

From the manufacturing sector, the main traditional and integrated management techniques were discussed. Integrating TQEM was suggested to achieve the objectives and enhance the mechanisms highlighted above. The view that construction management can adopt management methodologies and techniques from the manufacturing sector is widely accepted. This is mainly because in manufacturing and construction work environments, the quality and environment features of work as received by customers is formed by: (i) the end product or service, (ii) all the transformation processes, and (iii) the input used to provide the final goods and services.

At present, there is no single study on sustainable construction that applies TQEM. This indicates that despite the wide interest in improving quality, environmental and sustainability for the industry, contractors are short of management-based strategy for performance improvement towards sustainability. The separation of TQM and EM functions could be counterproductive to effective resource allocation and could make there interaction less effective. TQEM allows identifying customer preferences, doing the job right the first time, taking a systems approach, and making continuous improvement in the UK construction industry. As the distinction between the products, services and processes that transform resources into value are ambiguous in the construction industry; *adapting* rather than *adopting* TQEM is suggested. The next chapter examines the concept of TQEM.

CHAPTER FOUR

TOTAL QUALITY ENVIRONMENTAL MANAGEMENT

CHAPTER FOUR: TOTAL QUALITY ENVIRONMENTAL MANAGEMENT

4.1 Introduction

There can be little doubt that almost all construction organisations, like all businesses in the manufacturing sector, face increasing pressures to demonstrate their environmental awareness (Nash *et al.*, 2006; Green *et al.*, 2007). Such pressures come from clients, investors, customers, regulatory bodies and more generally, the public. Although the construction process can be compared with the manufacturing process, the design and production of a building differs in many ways from the design and manufacture of products, as discussed in the previous chapter. Therefore, this chapter highlights the evolution of TQEM's two sub-systems of TQM and EM and its key elements in order to justify its use for construction sector.

The separation of TQM & EM functions could be counterproductive to effective resources allocation. TQEM is structured around two management concepts of TQM and EM. These two sub-systems are brought together through their management approaches to support core contractor's business. This aims mainly to overcome the independent EM and TQM operations that lead to competitive demand for resources or priority attention (Griffith *et al.*, 2000). In construction organisations, two distinct tiers of management are developed within each sub-system. One delivers specific management functions throughout the corporate organisation, while the other delivers specific functions at the construction project level. TQEM could be the solution for more effective interaction between theses two tiers of management.

The adoption of EM in construction has been relatively slow compared to other industrial sectors. Spiralling demands for more environmentally empathetic and sustainable construction and, in particular, more stringent regulation, mean that EM will become a prominent consideration in the management of construction processes (Watson *et al.*, 2000:261). This was stimulated by the introduction of the BS 7750 specification for environmental management systems and its counterpart ISO14001, and Environmental Management Systems (EMS) such as the Eco-Management and Audit Scheme (EMAS).

This interest may follow in much the same way as the management of quality which has become an established aspect of construction management over the last 20 years. It is appreciated that some of the early experiences with quality systems development and implementation may have fostered a lack of initial interest in environmental management practices (Watson *et al.*, 2000: 253). The TQM implementation process enables construction companies to fully identify the extent of their operational activities and focus on customer satisfaction (Oakland *et al.*, 2006; Tang *et al.*, 2005; Thorpe *et al.*, 2004). BSEN ISO 9000 series of standards provides guidance for implementation.

TQEM was suggested by the Global Environmental Management Initiatives (GEMI) 1991 and the Council of Great Lake Industries (CGLI, 1993). TQEM is composed of four paradigms: (a) Total: Involving the entire organization, supply chain, and/or product life cycle, (b) Quality: With its usual ‘zero defect’ definitions and all its complexities, (c) Environmental: strategic environmental management approach (d) Management: The system of managing with steps like Plan, Organize, Control, Lead, Staff, provisioning and organizing. As defined by the International Organization for Standardization (adapted from ISO: 8402, 1994), TQEM is a total applied system approach and an integral part of high level strategy. It works horizontally and vertically across functions and departments, involving all employees top to bottom, and extends backward and forwards to include the support chain and the customer chain (Hoffman, 2000). It attempts to maximize the competitiveness of an organization through continual improvement through the whole life value analysis of the project (Wagner, 2007; Griffith, 2002). This chapter highlights Environmental Management (EM), Total Quality Management (TQM) and Total Quality Environmental Management (TQEM) evolution, process, tools and measures. TQEM’s role in performance-improvement is also included.

4.2 Environmental Management

Research related to environmental management in construction management is still in its infancy. The studies to date have primarily emphasized environmental issues relating to process technologies, quality, new product development, and supply chain management. This section reviews the evolution of environmental management, which has generated a wide range of tools, techniques, standards and frameworks.

4.2.1 Environmental management in a historical context

Environmental management strategies have evolved for more than three decades as strategies for resolution of environmental problems associated with industrial and business activities (Welford, 2000; Revelle, 2000; Sroufe, 2003). It can be seen that the increasing pressure on industry to address existing and potential environmental issues has progressively moved environmental management from focusing on regulatory requirement such as limited recycling to more consideration to environmental management dimensions and effects on decision making (Sroufe, 2003). The following lines highlight EM evolutionary process, which was divided into four main streams by Etzion (2007).

4.2.1.1 Industrial Environmentalism

Corporate environmentalism was born in the early 1960s attached to issues such as automobile emissions and oil spills. Moreover, despite the external criticism, industry treated the problem separately wishing that it were going to be solved by technology development. Such environmental management was handled as an operating line function within business organizations. Environmental management effort, however, was focusing on pollution control (the visible form).

4.2.1.2 Regulatory Environmentalism

The Environmental Protection Agency (EPA) was born in 1970 to carry on the environmental legislation. Thus, many regulatory structures were conceptualized, developed and institutionalized. Therefore, organization strategies were increasingly defensive driven by government regulation more that environmental concerns.

4.2.1.3 Environmentalism and Social Responsibility

Between 1982 and 1992, business and industry’s environmental management was evolved in importance. Thus, their objectives shifted from regulatory compliance toward economic efficiency. The drivers here, however, beside the previous regulatory motive are cost factors, liability concerns, public scrutiny and the indirect impact of regulation.

4.2.1.4 Strategic Environmentalism

With the increase of the environmental pressure from the government, NGO, and public awareness, a new strategic approach was developed. There are three stages towards environmental strategy: (a) pollution prevention, (b) product stewardship and (c) the development of clean technology (Welford, 2001: 77). Subsequently, Etzion (2007) suggested empirical and conceptual constraints on quality management to overcome these barriers. This implies that contractors' efforts to reduce external environmental costs often lead to identification of hitherto-ignored or undeveloped profit possibilities. This would be surprising from the standpoint of regulatory environmentalism theory, discussed previously as strategic environmentalism utilizes available information about the potential costs and benefits of projects.

The environmental evolution, highlighted above, shows an increasing demand for a change to more sustainable perspective. During recent years, the field of EM has witnessed environmental research gaining a secure foothold, especially in quantitative terms. Therefore, contractors should develop a strategic EM approach through: 1) specifying requirements, 2) assigning responsibilities, and 3) implementing mechanisms (Watson et al., 2000: 293). This is because on the ideological and symbolic level, strategic EM constructs products and companies as 'green' and legitimizes the primacy of corporate management's role in addressing environmental problems (Etzion, 2007). On the material level, strategic EM is a set of practices, tools and techniques that ameliorates the more egregious environmental consequences of industrial production as the following section indicates (Friedman, 2003). The EM evolution, highlighted above, has developed many environmental techniques, programs, systems and standards some of which are highlighted below.

4.2.2 Environmental Management Programs

The EM program is the organisational approach to formalising the means of achieving environmental; policy, aims and objectives (Watson *et al.*, 2000:274). The objective is for the organisation to establish and maintain an EM programme. According to Watson (2000), any EM programme should identify and specify the following:

- The environmental objectives that are top be achieved;
- The means of achieving these objectives;
- The mechanisms for managing changing circumstances; and
- The corrective actions needed should difficulties arise.

The Strategic EM approach, which was suggested for contractors in the previous section, is attached with a set of programs, techniques and systems (Etzion, 2007). Table 4-1 illustrates the strategic EM selection of programs according to Friedman, 2003. Enhancing these programmes depends on the nature and the scope of the environmental problem, the degree of comprehensiveness of analysis, and the business implications of its resolution.

Table 4-1: Environmental Management Programs

Environmental Management Programs	**Description**	**Primary utility**
Pollution Prevention	A common program that aims to reduce or eliminate pollution prior to creation	Provides understanding of the financial and environmental benefits of pollution reduction
Extended Product Responsibility	A life cycle base approach helps in risk management along the product life cycle	The input of this programme is identifying risks and the responsibilities of each members of the value-chain. More importantly, it enables managing those risks in association with product systems
Design for Environment (DFE)	A programme for designing more ecologically and, economically sustainable product systems. It brings the physical product life cycle into product development.	It provides the input to developing processes to improve a product's environmental performance

(Source: Friedman 2003)

The EM programmes are fundamental to the establishment of the EMS. The environmental programs, summarized in the table, are seen as the core mechanism transferring organisational environmental policy into procedures and working practices (Watson *et al*., 2000: 274). The present research considers it vital for contractors to commit to DfE. This is seen as important for encouraging early interest in quality and environment performance improvement, and for developing and maintaining environmental leadership towards sustainability. The previously highlighted initiatives have made it possible to set out challenges for contractors and make clear proposals regarding progressive implementation of the environment quality and sustainability issues drawing from various national experiences. Having presented major works outlining the historical development of construction performance improvement initiatives, it is necessary to define the various construction performance improvement objectives.

Strategic EM approach was suggested in the previous section for better alignment with contractors' core strategies. Strategic EM comes loaded with cogent analysis, precise time- and money-saving procedures. Therefore, the highlighted EM programs have to do with the discovery of cost savings and market opportunities from reducing environmental impacts. This selection of EM programs could assist contractors in moving beyond mere compliance, mainstream their corporate environmental planning, and turn environmental management into an integral, profitable part of their firms.

4.2.3 Environmental Management techniques

Numerous EM techniques can be found in the literature. The following table highlights the main techniques and each of them primary utility in integrating EM.

Table 4-2: Environmental Management Techniques

Environmental Management Techniques	**Description**
Life Cycle Assessment (LCA)	Analysis of energy and material utilization with product environmental impacts through its life-cycle (from cradle to grave). It provides a deep understanding of energy and resource utilization in the product life cycle and the environmental impacts to develop the environmental performance of the system.
Full-Cost Accounting (FCA)	Linking organisations' internal environmental costs (i.e., costs for regulatory compliance or hidden expenses, etc.) with external environmental costs (such as using non-renewable resources, cleaning up waste, disposal sites, etc) within the accounting process. This shows the

	economic consequences of environmental performance.
Life-Cycle Management (LCM)	LCM integrates life-cycle thinking into operations and product management. Upstream and downstream can be included qualitatively and quantitatively. In general, however, the two streams are not normalized to a functional unit as in life-cycle assessment. Moreover, this technique is used in operations and product systems to manage risk and opportunities through the product life cycle with a cost matrix in most cases.
Risk Management (RM)	RM guides the necessary actions to reduce the risk associated with products and operations, to minimize risks and interruptions to the business.
Risk Assessment (RA)	RA characterizes the potential impact of human or ecological exposure to chemicals. It illustrates the quantitative and qualitative expressions of risk.
Auditing	Auditing is the process of justifying the organisations' compliance with regulatory requirements, internal polices, or other established standards. It provides information about the organisation's management and equipment performance.
Environmental Impact Assessment (EIA)	EIA evolves study into the adverse and beneficial effects that construction, maintenance and operation of proposed development or land use change will have on the environment including people. This technique compares enhances all beneficial impacts of alternative or maintaining courses of action, and the long and short term impacts.

(Source: Friedman 2003)

These techniques have a strong foundation to be enhanced in the construction industry. This is due to its ability to facilitate examining the various advantages to an organisation of considering the life-cycle of their projects processes with a view to the introduction of environmental improvements. The technical framework of an LCA, for example, is outlined comprising of four separate but interrelated components: goal definition, inventory analysis, impact assessment and interpretation. Contractors, in this case, could focus on the process of quantifying energy and raw material requirements and environmental releases throughout the life cycle of a project or process. Yet, selecting the tools based on the organisation’s considerations can reduce administrative burdens, provide flexibility to decide how to implement environmental improvements, and work toward superior environmental performance (Steelman, 2006:66). In practice, however, one interest may be served to the exclusion of others, and this is a charge that often has been levelled at EM techniques (Friedman, 2003). If these techniques are used to serve some interests at the expense of others, they are likely to lose their value as alternative policy tools.

4.2.4 Environmental Management Systems and Standards

An Environmental Management System (EMS) is “the organisation’s formal structure that implements environmental management” (Griffith, 1997: 161). BS 7750/ISO 14001 Specification for Environmental Management Systems requires that the organisation develop, implement and maintain an EMS to insure that its activities conform to the environmental policy, strategy, aims, objectives that it has set (Watson *et al.*, 2000: 261). The authors suggest that, for establishing EMS, an organisation should seek to develop an EMS manual; to implement the requisite procedures in its business, operations, to educate the organisation; to maintain the procedures, and to review and update them on a continuous basis.

BS 7750/ISO 14001 suggests the sharing of organisational systems and resources, provided that the existing system is itself recognised, for example an ISO 9000 QMS, as explained later in this chapter. As BS 7750/ISO 14001 presents a specification for any sector of business seeking to establish an EMS, it sets out only the basic requirements in key sections (Watson *et al.*, 2000: 262). For an organisation to maximise the use of an EMS, the concepts of EM and its application should be viewed from a broad sustainable perspective.

The recognised advantages of using a system approach for EM are: identified framework; uniform practices; documented evidence of compliance; improved communications; inherent preventive and reactive management capability; more rapid respond to organisational problems; and external recognition, marketability and commercial competitive advantages (Watson *et al.*, 2000: 267). One of the main arguments for EMS implementation is the assumed reduction of command and control regulation from the authorities when a company can show that it is taking charge of its own environmental situation and has it under control, i.e. taking the initiative themselves (Green *et al.*, 2007). It could also reduce trade barriers world-wide in companies and make it easier to compare environmental performance in different companies and between one company's operations in different projects (Etzion, 2007).

EMS could be developed separately, until the guidelines of how it can be co-ordinated with other management systems are more established (Hoffman, 2000). Out of the available EMS, the ISO 14001 standard is recommended for allowing variations in detail and complexity, extent of documentation, and the amount of allocated resources to suit the size of a contractor (Love, 2000). One of the EMS's advantages, that contractors may experience, is the possibility to perform more structured environmental audits using aggregated environmental indicators, as explained in the following section.

4.2.5 Environmental Indicators

Environmental indicators are useful tools by which contractor's environmental performance can be assets. The purpose of the indicators is to establish benchmarks against which performance can be measured (The KPI Working Group, 2002: 7). As can be seen in table 4-3, indicators are the methods that should be harnessed by different decision makers for managing complex issues using simple units of measure (Wagner; 2007: 3). EM audits are "the periodical detailed evolution of the organisation's EMS to determine its effectiveness in satisfying the environment policy" (Griffith, 1997: 187). Thus, an EM review should be conducted at appropriate intervals, first, to monitor the system and, second, to ensure that the system continues to meet the requirements of the standards and current legislation. Sustainable performance indicators for construction were developed by Hassan (2006).

To implement this effectively, contractors should develop environmental indicators to determine the organisation aspects to be audited (Watson *et al.*, 2000: 278). Different internal and external users of environmental indicators can be seen in Table 4-23. According to Egan (2002: 4), the construction industry provides a simple starting point for measuring performance and benchmarking by providing definitions for economically used indicators, industry performance graphs which allow a simple analysis, and radar chart which acts as a simple performance scorecard. In 1999 a set of ten financial and non-financial Key Performance Indicators (KPI) for the construction industry was launched by the Construction Best Practices Program (CBPP), which are updated annually. Nevertheless, environmental performance indicators are not mentioned clearly and separately. The construction industry uses these KPIs as criteria to measure performance.

Another approach for performance measurement is the balance scorecard established by Kaplan and Norton (1996) which shows a full picture of an organisation's performance. The 'balance' in the balanced scorecard refers to the recognition that to achieve a comprehensive view of an organization's performance, it needs to be seen from different viewpoints, or perspectives. In the past, organizations only tended to look at financial measures, which are lagging indicators. Leading indicators come from three other perspectives, so that there are four perspectives in all:

- Financial perspective: Contains the financial results such as profit, return on capital, cash flow, and margins.
- Customer perspective: The customer is concerned with: Time. Quality, Performance and Service, and Price or rate.
- Internal (business) process perspective: Involves Operations management processes, Customer management processes, Innovation processes, and Social and regulatory processes.
- Learning and growth perspective: Includes human, information and organizational capital or capacities.

These four perspectives could be adapted for contractors, yet, within these perspectives, it is important to develop environmental indicators for contractor's project and management procedures. For example, a main contractor (within main novated D&B strategy) can asset the sustainability of potential suppliers and specialist subcontractors for a project, by asking them to provide information about how they perform against a range of indicators. Another potential benefit of this setting of indicators across construction supply chain will enable identifying strength and weaknesses and assess their ability to improve over time.

Table 4-3: Environmental management indicators' users

Indicators' Users	Objectives
Corporate manager	o To monitor an organisation's "environmental" development in relation to strategic targets (derived from concern about future impacts of environmental developments); o To identify most harmful wastes and emissions; o To communicate corporate environmental performance/attitude to stakeholders (shareholders, environmental authorities, clients); o To compare performance with preceding periods/years.
Project manager	o To identify opportunities for improvements in efficiency; o To convey information on the efforts to limit environmental impact of site operations
Market manager	o To identify new market opportunities; o To defend market positions. Reference point competitors. Purchasing manager Accountability. Business-to-business relations.
Environmental authorities (compliance situation)	o To test compliance with authorities' permits (national) o In voluntary agreements - to communicate a firm's effort towards environmental improvement. o To construct databases those are helpful in developing and implementing a government's environmental policy.
Investors and shareholders	o To indicate for financial performance; this may indicate environmental liabilities that could affect financial performance.
Performance Consumers	o To meet needs of clients.

(Source: Sroufe, 2003)

4.2.6 Research in environmental management

When the literature on EM is broadly examined and synthesized, two dominant perspectives can be found: (i) the External constraint and (ii) the Component perspectives (Meldenson, 1999). The first stream, which historically dominated much of the operations management literature, considers environmental performance requirements to be an externally imposed constraint on the operating system (Angell and Klassen, 2006). In contrast, the component perspective recognizes environmental issues, with implications for operations strategy. This perspective explicitly recognizes the potential for operations to plan for, influence and leverage environmental issues for competitive advantage both internally and externally (Ofori *et al.*, 2002).

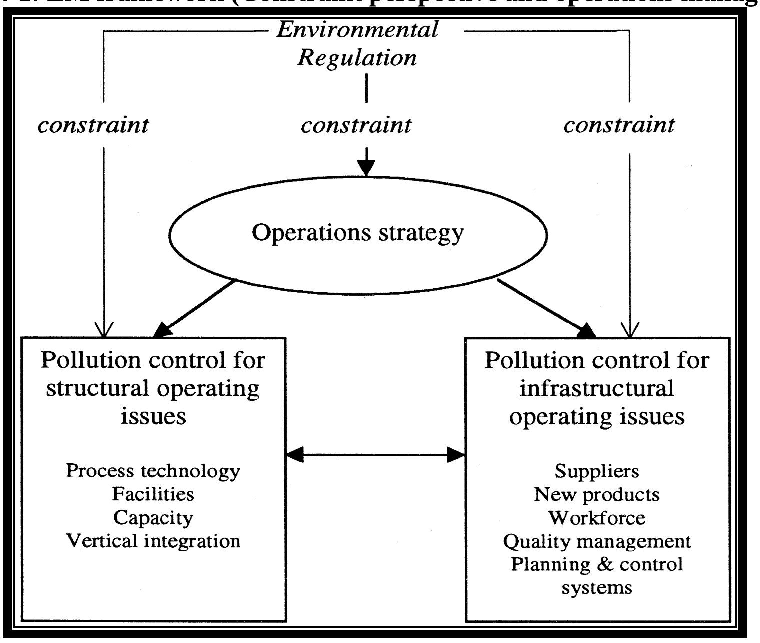
Historically, EM was viewed as a narrow corporate legal function, primarily concerned with reacting to environmental legislation. Research and managerial action focused on buffering the operations function from external forces in order to improve efficiencies, reduce cost and increase quality (Green *et al.*, 2007). This Constraint perspective for EM is seen as an emerging and innovative field (Elgar *et al.*, 2002: 133). Thus, few strategic frameworks can be found as keys for implementing strategic EM into business planning. Differences can be found between two extremes of the strategic EM. The challenge to any strategic vision at the core nature of business stems from the environmental decision making process (Meldenson, 1999: 12). Mendelson suggested that EM integration requirement are:

- Making EM complement with the overall business strategy.
- Reflecting business logic and priorities into changing environment communications using clearer concepts and terms.
- Adopting a way to measure the real cost and business benefits.
- Making EM part of the business culture.

Meldenson (1999) refereed to the EM two main streams by (a) an interactive EM that fits with business strategy and talks business language and (b) standing alone EM that is separated from the business strategy and decision making criteria.. Most of the EM frameworks were developed for the manufacturing sector. Hence, the majority of these frameworks are strategic business oriented rather than operational oriented, as the research related to the natural environment in operations management is still in its infancy (Arditi *et al.*, 2002). This suggests the possibility of adapting it for the construction industry.

In this context, the EM framework developed by Angell and Klassen (Figure 4-1) provides an operational approach for EM. This framework is structured along two dimensions: the level of analysis and the process of environmental improvement. Angell and Klassen, 1999, through a focus group study, identified some environmental constraints which were subsequently mapped onto this framework. This framework captures the link between EM and QM. This link has the potential for building an understanding of environmental issues and improving practice in the areas of strategy, quality, supply chain management, and technology. Research on intra- and inter-firm diffusion of best practices, environmental technology investment, and transfer, and measurement of environmental performance promises to lead to a more integrative view of environmental operations management.

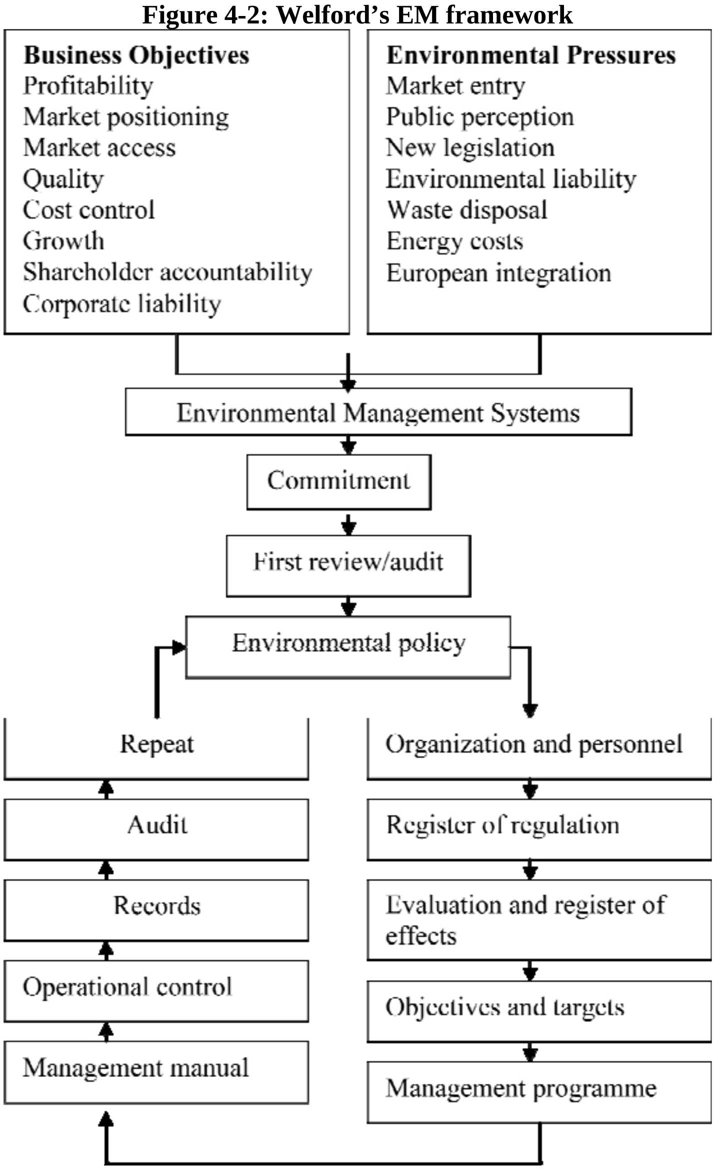
Figure 4-1: EM framework (Constraint perspective and operations management)



(Source: Angell and Klassen 1999)

In comparison, Welford EM framework, Figure 4-2, provides a strategic business approach. Welford, 1998, argued that environmental strategy formulation require deep internal and external analysis. Welford considered; environmental legislation, the green customer, cost reduction, and the new green market opportunities to be the key drivers for developing EM framework (Welford, 2001: 217). Yet, his approach does not take into account the non-environmental aspects of sustainable development (social and economical aspects). Welford's EM framework's (Figure 4-2), main shortcomings are: a) the lack of any information system that could have acted as a benchmark for future measurement, b) the ambiguous feedback loop that does not allocate recourses, requirement or responsibilities, and c) no consideration was given the different nature of EM implementation on the corporate and project-levels.

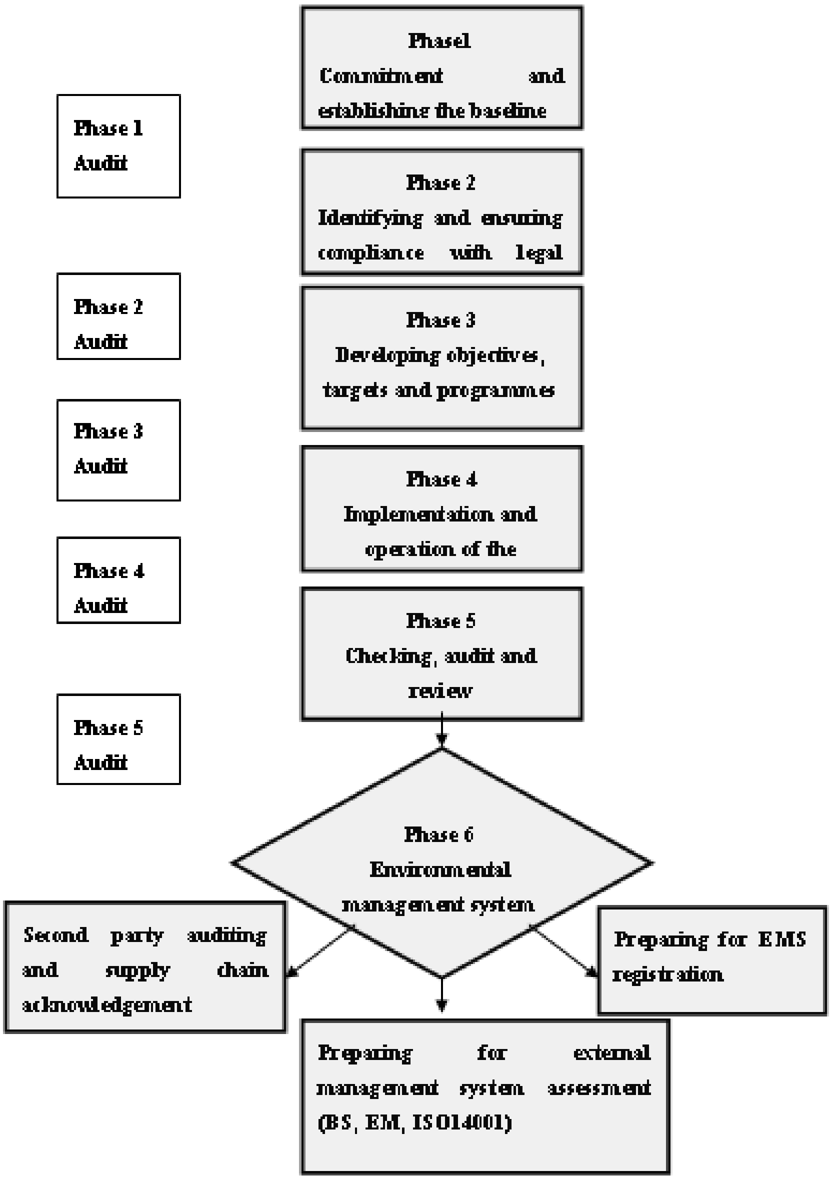
Figure 4-2: Welford's EM framework



(Source: Welford, 1998)

In 2003, British Standards introduced BS 8555 a guide to the implementation of EM including the use of environmental performance evaluation. As can be seen in **Error! Reference source not found.**, BS 8555 breaks the EMS into 6 phases. It may be anticipated that ISO14001 and EMAS are roughly equivalent to achieving Phase 6. This Standard provides guidance to any type organisations on the phased implementation, maintenance, evaluation, and improvement of Environmental Management System (EMS). It also includes recommendations on: (a) the integration of environmental performance evaluation and (b) the alignment of an EMS with other management systems. Hence, the framework appears to be very conceptual, difficult to implement, somewhat subjective and difficult to defend EM corporate and operational-levels.

Figure 4-3: BS 8555 EM framework



(Source: British Standards 2003)

The development of EM frameworks reflects the EM evolution, explained in section 4.2. Improving the environmental performance has been a constant source of review to move it from the regulatory to strategic approach. The research in this area demonstrates an interest in specifying the EM issues on the strategic and operational levels. From EM perspective, TQEM framework for D&B contractors should consider corporate and project level implementation and should develop EM approach through three principles areas of considerations: 1) specify requirements, 2) assign responsibilities, and 3) implement mechanisms. This is seen important for encouraging early interest in quality and environment performance improvement, and for developing and maintaining environmental leadership towards sustainability. Having presented major works outlining the historical development of EM frameworks, it is necessary to define the EM integration levels.

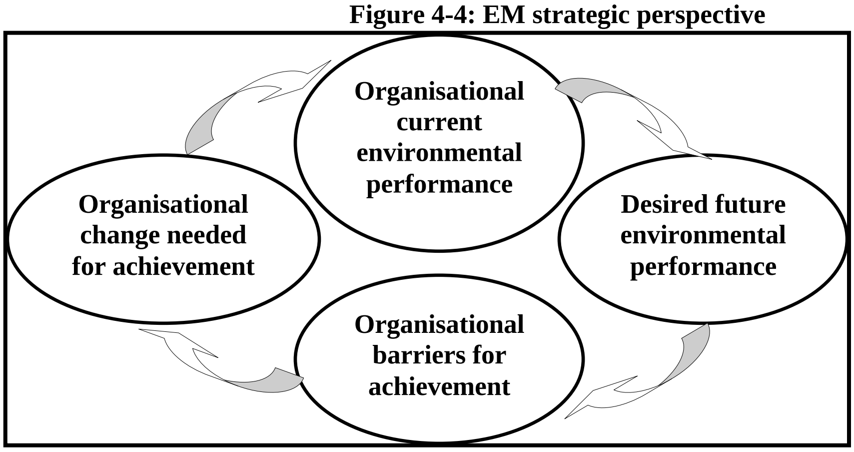
4.2.7 EM Integration Levels

A survey of the literature points two environmental management research streams that relate the EM integration in an increasingly focused manner: strategic business perspective and operational and processes perspective.

4.2.7.1 Corporate Level

To clearly demonstrate commitment to environmental issues, contractors should establish and maintain EMS. This corporate level will ensure that the effects of an organisation's activities conform with environmental legislation and also to its own stated environmental management policy, objectives, documented principles, and procedures (Watson *et al.*, 2000: 265). Figure 4-4 illustrates the formulation of EM on the corporate level. Environmental business strategy could be defined as the response to the relationship of an organisation's products, services and activities with its natural environment (Pearce, 2006).

Figure 4-4: EM strategic perspective



(Source: Watson *et al.*, 2000)

According to Lawrence (2002), for integrating EM on the corporate level, the following points need to be considered:

- Industry characteristics: there may be industry environmental standards or targets that influence the activities within the organisation.

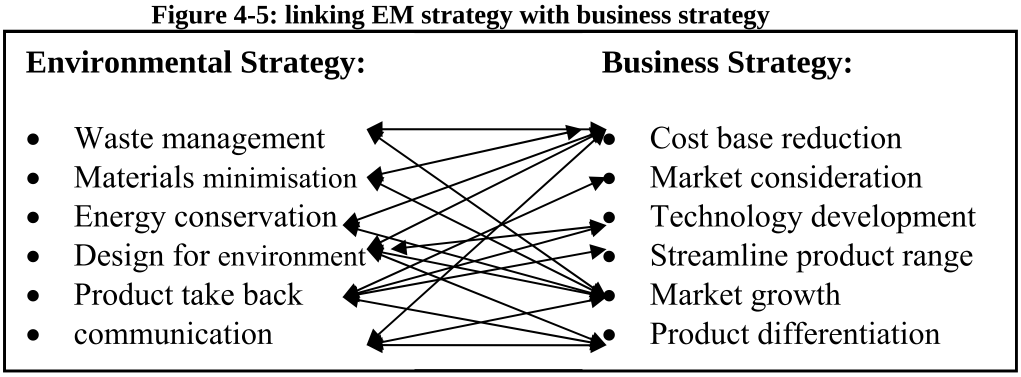
- Natural resources: natural resources encompass the resources consumed by the organisation in producing energy, products and providing services, such as transportation.

- The environmental impact of construction processes.

- Consideration of both the local and global community highlights issues related to the impact of an organisation's products, processes, and services on the human community.

Figure 4-5 presents the link between EM and business strategy. Angell and Klassen, 2002, enhanced porter fife forces for integrating EM into business strategy. This approach did not consider implementing EM on the operational level.

Figure 4-5: linking EM strategy with business strategy



(Source: Angell and Klassen, 2002)

4.2.7.2 Project or operational perspective

EM during the project evaluation stage is manifest in the process of Environmental Impact Assessment (EIA) (Watson *et al.*, 2000: 279). The term 'operations management' has traditionally been associated with manufacturing activities but can also be applied to the service sector (Waver, 1996). Operations management is defined as the design, operation, and improvement of the systems that create and deliver the firm's primary products and services (Angell and Klassen, 2002). According to Angell and Klassen (2002), a particular focus should be given to integration EM into the operational levels in terms of: Capacity, integration, infrastructural decisions, suppliers, new products, workforce, planning and control systems.

Some researchers tend to focus on only one of the previous elements. Arditi (2002) found that capacity must be added on two fronts simultaneously: 1) to produce the product, and 2) to recycle all or part of the product. Ofori *et al*. (2002) focused on integration or logistics and environmental supply chain concepts. Infrastructural operating decisions are 'viewed as much more tactical in nature because of the myriad of on-going decisions they encompass, the need to link them to specific operating aspects of the business, and their tendency not to require large capital investments at a single point in time' (Hassan, 2006). Research in new product development or process management has started to study mechanisms for, the process of, and outcomes from the inclusion of the natural environment in decision making (Love, 2002).

Others tried to group EM project-level elements in three main functional areas, of contract administration in developing a contractor's EM on project-level (Watson *et al.*, 2000: 291): a) project environmental planning: concerned with environmental consideration during the tendering process and the pre-contract process up to commencement on site, b) project environmental familiarisation: concerned with environmental consideration at commencement onsite, and c) project EM: concerned with environmental consideration during the administration of the production process on site.

To achieve effective transfer of this information into application, the project-level EM must clearly: (i) specify environmental requirements, (ii) assign management responsibilities and (iii) implement control mechanisms (Watson and Griffith, 2004:441). Research activity directed toward EM integration variables in business strategy and operations. However, the field remains largely undeveloped. In fact, scholars have often been responsible for initially identifying critical linkages between environmental issues, business, and operations. Environmental management could benefit from total quality management researches and practices which are investigated in the following section.

4.3 Total Quality Management

The development of quality management to the state as known it today has gone through several stages and has developed many tools and frameworks.

4.3.1 TQM Evolution

The evolution of quality management has led to the development of essential processes, ideas, theories and tools that are central to organisational development, change management, and the performance improvements that are generally desired for individuals, teams and organisations (Sroufe and Curkovic, 2007a; Whiteman and Haupt, 2004). Feigenbaum (1991) identified five stages in the evolution of quality control and management: 1) operator (craftsman) quality control, 2) foreman quality control, 3) inspection quality control, 4) statistical quality control, 5) total quality control, and 6) strategic quality management.

4.3.1.1 Operator (Craftsman) Quality Control

Operator quality control was inherent in manufacturing up to the end of the nineteenth century. Under this system, one worker, or at least a very small number of craftsmen were responsible for the manufacturing of a complete product. It was considered that a well-performed product is the natural outgrowth of reliance on a skilled craftsman for all aspects of design, manufacturing, and service (White and Haupt, 2004). The direct contact between producer and customer began to diminish with the advent of the industrial revolution and the concept of labour.

4.3.1.2 Foreman Quality Control

The development of power-driven machinery and resources of mechanical power in the industrial revolution brought the factory system together with the concept of division of labour. The factory usually subdivided former trades into multiple specialised tasks. Although this resulted in increased productivity it also brought in new quality problems. With the craft tasks divided between many workers, the responsibilities of those workers were no longer that of satisfying the customer. Thus, the responsibility here became one of "making it like the sample" (Juran, 1995). In addition, products that consisted of the assembly of bits and pieces demanded that those pieces be interchangeable. This also brought in the problem of variation, requiring a greater precision in machinery, tools, and measurements.

4.3.1.3 Inspection Quality Control

In theory, since every part that is worked on is held in place in the same way, a high degree of inter changeability is expected. Nevertheless, parts could still deviate from one another due to improper mounting, defects in materials or worn tools. With very little understanding of the nature of process variation and the resulting product variation coupled with limitations of quality planning during those times, a lot of defective products were produced during manufacturing. In order to minimise problems at assembly a system of gauges were developed. Taylor, in the early 1900s, formulated the “principles of scientific management”. His concept was to separate the planning function from the execution function. Top managers showed very little interest in quality improvement or prevention of defects and errors, relying instead on mass inspection. With this method of quality control manufacturers were able to ship defect-free products but at a great cost.

4.3.1.4 Statistical Quality Control (SQC)

SQC is the application of statistical tools and methods for controlling quality. Tools like control charts were used to identify quality problems in production processes and to ensure a consistent output. Shewhart (1986) recognised that variability cannot be totally eliminated, although it could be understood using principles of probability and statistics. He recognised that, even the same part produced by a single operator on a single machine was likely to show variation over time. The issue, therefore, is how to distinguish between acceptable variations from fluctuations that indicate trouble. The entire analysis grew out of Shewhart’s concept of statistical control, and he developed statistical techniques to determine these limits.

4.3.1.5 Total Quality Control

Japanese manufacturers during the 1960s changed the emphasis from quality control to a quality assurance approach. Quality assurance involves a set of activities designed to ensure that the development processes is adequate to insure that a system will meet its objectives, whilst quality control is a set of activities designed to evaluate a developed work or product. Thus the emphasis here moved from that of product oriented to a process oriented. This required more of the business functions of the organisation to be involved in the management of quality. This finally led to a "total" approach to quality management whereby everyone in the organisation is involved in developing an improvement and prevention orientation which focuses upon the customer through teamwork.

4.3.1.6 Strategic (Total) Quality Management

In the face of intense global competitive pressure a new vision towards quality began to emerge. For the first time top managers began to link it with competitive advantages and profitability. Quality was here defined from the customers' point of view and linked to the company's strategic planning process. Thus quality was no longer an isolated, independent function, dominated by technical experts. This approach incorporate elements of the first quality eras, but goes a step further by linking it with continuous improvements and high level communication and practices are now required in order succeeding in the competition (Landy and Conte, 2004).

Strategic TQM is the capstone of quality management. Feigenbaum defined TQM as: "An effective system for integrating quality development, quality maintenance and quality improvement efforts of the various groups within an organisation, so as to enable production and service at the most economical levels that allow full customer satisfaction" (Feigenbaum,1961). In this sense, TQM is a business method and proposed three steps to quality: quality leadership, modern quality technology, and organisational commitment (Sroufe and Curkovic, 2007a).

In its historical evolution, TQM has been the foundation for many management approaches i.e. Crosby fourteen steps, the seven basic tools, Taguchi Methodology, Zero Defect, Malcolm Baldridge National Quality Award, and TQM Holistic approach. However the last two concepts are seen to be more relevant to this study. This is because TQEM enhances TQM holistic approach and TQEM could benefit from the American contractors experience with Malcolm Baldridge award.

TQM Holistic approach refers to long-term success that views continuous improvement in all aspects of an organisation. It aims to radically transform the organisation through progressive changes in the attitudes, practices, structures, and systems (Whiteman and Haupt, 2004; Curkovic and Srouf, 2007).

Malcolm Baldridge annual award for the USA firms has excelled in quality management and quality achievement. Established in 1987, the award is named after the quality-management champion Malcolm Baldridge. This award may be given to a manufacturing company, service company, or small business. The award is managed by the National Institute of Standards and Technology and conferred by the American Society for Quality. It is based on seven criteria: (1) leadership, (2) information and analysis, (3) strategic planning, (4) human resource development and management, (5) business results, (6) customer focus, and (7) customer satisfaction.

Similar to the environmental issues, quality, cost, timelines, and productivity were often viewed as conflicting elements that require trade-offs. Optimising these apparently conflicting objectives whilst their projects consistently rated above average quality and less than average cost appear to be a challenge for principle contractors. The TQM Holistic approach to long-term success views continuous improvement in all aspects of an organisation as a journey and not as a short-term destination (Besterfield *et al.*, 2002). It aims to radically transform the organisation through progressive changes in the attitudes, practices, structures, and systems (Whiteman and Haupt, 2004). Curkovic and Srouf, 2007, emphasized on TQM role in the creation of an environment that supports innovation, creativity, and risk taking in meeting customer demands, using participative problem solving that incorporates managers, employees, and customers.

4.3.2 TQM tools

The previously highlighted TQM evolution was aligned with the development of TQM implementation tools. Under this section the main tools of TQM is highlighted. These tools offer a means collecting, presenting, and analysing data (Table 4-4).

Table 4-4: TQM tools

TQM Tools	Description	Primary utility
Check sheets or tally sheet	This is a data-gathering tool useful for recording direct observations and helping to gathering facts rather than opinion about process.	The objective of the data collection determines the design of the record sheet used. The results obtained from tally sheets give the frequency distribution of the parameters concerned.
Pareto analysis	This is the analysis of data to identify the major problem	Without an analysis of this sort it is very easy to devote resources to

	areas.	addressing one symptom only because its cause seems immediately apparent.
Cause and effects analysis	This is away of mapping inputs that affects quality. It is usually presented in a diagram known as fishbone. The effect being investigated is shown at the end of a horizontal arrow. Potential causes are then shown as labelled arrows entering the main causing arrow.	By adding other arrows to each of the main arrows, the problems are reduced to sub-causes.
Force field analysis	The process begins with a team describing the desire change and defining the solution. After brainstorming to identify the favourable and unfavourable they are placed on opposite sides	This is a technique used to identify the forces that will either obstruct or help a change tat needs to be made.
Statistical Process Control (SPC)	This tool assists in terms of improving the quality in any transformation process within an organisation	SPC can assist operators of the process to: • Know whether the process is capable of meeting the requirements. • Know whether the process is meeting the requirements at any point in time. • Make correct adjustments to the process or its inputs when it is not meeting the requirements.
Affinity diagram	This is used to collect large amount of qualitative data and efficiently organise them into groupings based on similarities or relationships between them.	This tool aims to simplify complex problems through systematic grouping of the main ideas generated during brainstorming.
Interrelationship diagram	This tool identifies and describes the logical links among related concepts or ideas.	By focusing upon a particular idea, the interrelationship diagraph brings logical structure and relationships to the ideas. The nomenclature used describes processes, causes and results.
Tree diagram	This tool is a hierarchical structure of ideas. It is constructed by arranging the clusters from the affinity	Like the affinity diagram, since the construction of tree diagram is based on logic and analytical skills, it is possible to discover new groupings and branches and

	diagram horizontally.	also missing ones. It assists the team in understanding the sequence of events which either causes the problem or are required to affect a solution.
Matrix diagram	This is a two dimensional array that displays relationships between ideas, activities or other dimensions in such a way as to provide logical connecting points between each item. Numeric values or samples responding numeric values are used to indicate the strength of the correlation between them.	The usual symbols used are: 1. (λ) indicates a strong tendency of the product feature to satisfy that customer need. 2. (O) indicates a moderate tendency of the product feature to satisfy customer needs. 3. (Δ) indicates a weak tendency of the product feature to satisfy that customer need. While a blank cell in the matrix indicates that there is no relationship between two items.
Matrix date analysis	This technique is used to evaluate the numerical weighting of the relationships identified in the matrix diagram.	The technique employs factors analysis to prioritise the respective correlations between the relationships. This is useful in identifying product or service factors in terms of their preference by customers in the market place.
Process decision programme chart (PDPC)	This is a method of mapping out all the stages and contingencies in going from the problem statement to the problem solution. It is used to anticipate the unexpected and then plan for it.	The aim here is to proactively analyse failures and construct on papers, a run of the process so that the check part of the improvement cycle could be defined in advance.
Arrow diagram	It is basically a diagramming method for illustrating the sequence, precedence and the duration of events.	This is used to systematically plan or schedulable a task.
Control Chart	This is a graphical approach to monitoring the behaviour of the process.	It compares the ongoing variation with warning and action limits derived from the normal distribution.
Scatter diagrams	These tools are used to establish relationships between parameters or factors. It is generated by a simple X-Y plot of the two sets of data.	The resulting grouping of points will show whether there is a strong, positive/negative, or weak relationship between the parameters.
Stratification	This is the method of dividing	It provides the input to

	data into meaningful groups. It can be used to great effects with other techniques.	developing products and processes.

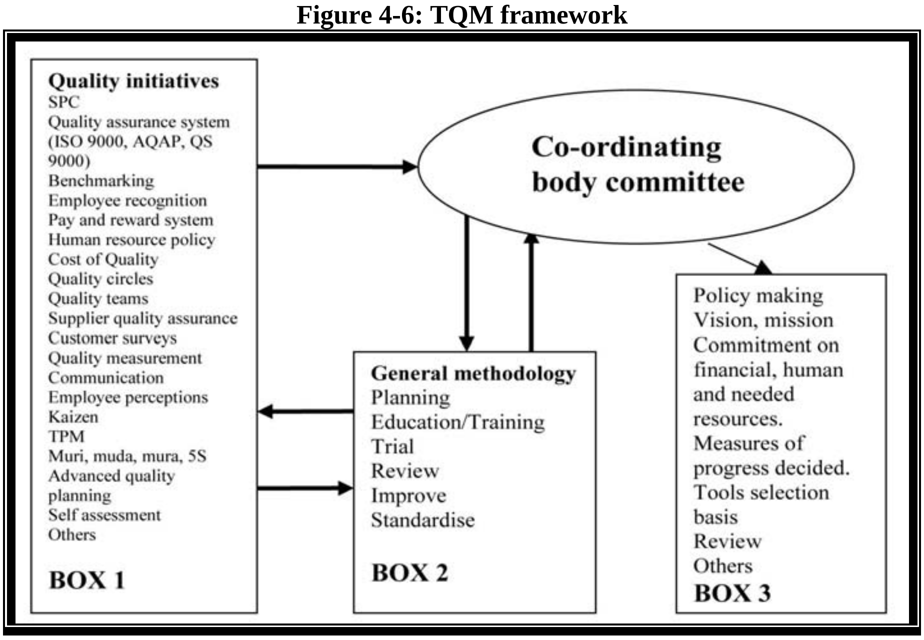
(Source: Friedman 2003)

PDCA may be more applicable for this study as PDCA cycle is a well established improvement technique. The idea is to constantly improve and reduce the difference between customers' requirements of the performance and the process. It is also known as the Deming cycle, although it was developed by Shewhart. It is about learning and ongoing improvement and the cycle repeats.

4.3.3 TQM Frameworks

TQM frameworks appear to be either conceptual or very complicated. The discussion here selected two examples. Figure 4-6, illustrates the TQM framework developed for the automotive industry by Yusof and Aspinwall, 2001. The main criticism about this framework is regarding the required resources; there were no time elements included, nor other necessary resources. Another aspect is in regard to quality being a cultural transformation. On the positive side, however, the simplicity built into the framework might make it possible to be understood by companies' managers.

Figure 4-6: TQM framework

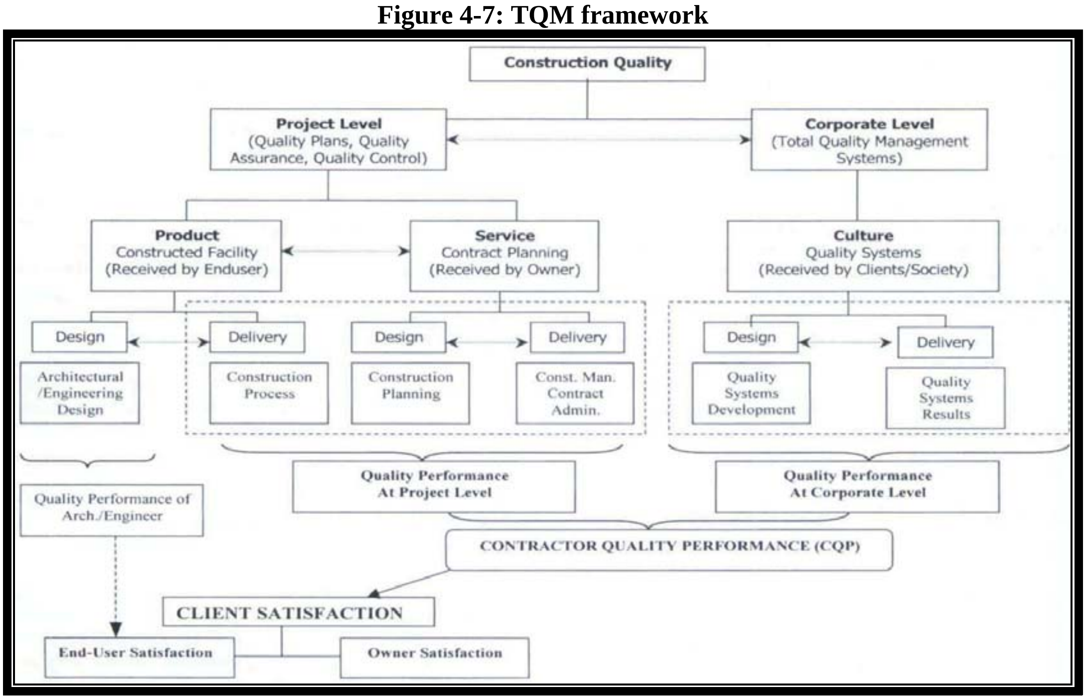


(Source: Yusof and Aspinwall, 2001)

Generic models were developed by Watson and Seng (2001) in order to guide them through the implementation process. The models have been developed based on feed back from the empirical studies. The authors suggested three aim issues for successful implementation: training and development of people; improved communication; and getting to know the client. Watson and Griffith (2004) developed QM implementation framework based on the European Foundation for Quality Management Business Excellence Model (EFQM). The authors enhanced the RADAR logic which refers to; the Results the firm is aiming for: Approaches to deliver the required results, to deploy the approaches in a systematic way, and to assess and review the approaches.

Within the TQM framework in Figure 4-7, quality is seen as an element that permeates every strategic decision, and is reflected in an organisation's outputs. The validity of these factors are tested and accepted in the manufacturing industries. The existence of these indicators in a contracting firm is anticipated to imply an established corporate quality culture. The corporate quality culture as defined by the corporate quality attributes is a critical player in achieving total client satisfaction for construction firms (Arditi *et al.*, 2002).

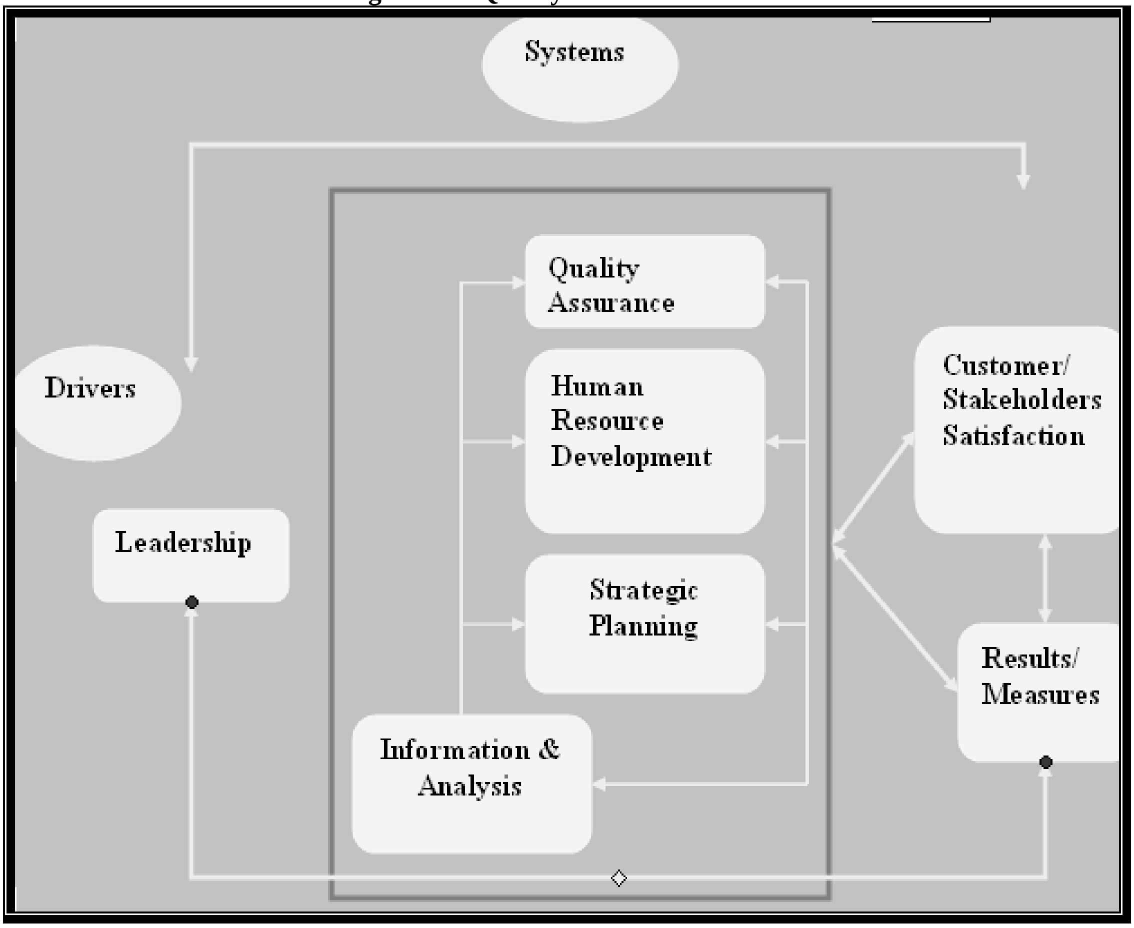
Figure 4-7: TQM framework



(Source: Arditi *et al.*, 2002)

Hence, from a contractor perspective, by using these corporate-level processes, it may be possible for owners to predict whether they will be satisfied with the quality performance of the firm at the corporate level. The original TQM framework of Wever (1996), illustrated in Figure 4-8, has been slightly modified in this model to apply to construction companies. Wever framework for quality is based on the seven Baldrige categories. As shown in Figure 4-8, visual reinforcement was given to the relationships between these categories. More consideration to the design and delivery should be considered from contractors' perspective.

Figure 4-8: Quality based framework



(Source: Weaver, 1996)

TQM research in construction industry has developed several means of achieving TQM. Some researchers selected single statistical or quality management techniques such as Total Cost Assessment TCA, Plan-Do-Check-Act method (Sroufe and Curkovic, 2007; Ahmed, 2001; Tang *et al.*, 2005). Others built a TQM framework for 'vertical' integration that considers different management level within the company (Pheng and Teo, 2004; Thorpe and Summer, 2004).

Pheng and Teo (2004) research on the application of TQM to construction site proves TQM role in speeding-up projects while increasing profitability. Thorpe and Sumner (2004) conducted a large study among 1500 construction firms in the U.S.A. The study proves that there are substantial economic benefits that can be attained through the implementation of TQM. Love *et al.*. (2000) highlighted how implementing TQM in construction industry affects customer satisfaction. The authors declared that, "For the first time an empirical study has confirmed that implementation of TQM is positively associated with home-buyer satisfaction". Watson (2004) suggested the application of TQM in a dynamic control feedback loops to the problematic issue of controlling 'as designed' compared to 'as built' on construction projects.

This section has highlighted several TQM. These approaches seem to be very conceptual and information intensive. This leads to difficult implementation for TQM. The basic elements of TQM framework should include a strong stakeholder's focus, a high level of senior management commitment to meeting their needs and expectations, and a "tool kit" that includes teamwork empowerment, continuous improvement, root cause analysis, and a prevention approach. Each of these elements is highly relevant to environmental management encountered by formidable regulatory challenges and increasing of customers and stakeholders expectations. The integration of TQM has been considered from two main extremes. The corporate level (vertical integration) and project level (horizontal integration), as discussed in chapter two.

4.4 Linking TQM with EM

The TQM integration levels discussed in the previous section appear to be similar to EM integration levels mentioned earlier in this section. Thus, this is not the only similarity between EM and TQM that can be demonstrated by this area literature. In fact, TQM has many analogies with EM and even the 16 principles of the Business Charter for the Sustainable Development (Green *et al.*, 2007). Common points between quality and environment are: customer satisfaction, prevention, supplier partnership, audits and ISOs' shared points.

4.4.1 Customer satisfaction

As for TQM, the environmental programmes also focus on the process in order to eliminate, with a continuous improvement approach, all possible inefficiencies, keeping in mind the final customer, who may be the end user of the product, the surrounding community or public authorities (Curkovic and Srouf, 2007).

4.4.2 Prevention

By extending the well-known idea that "quality is free" we can assert that the programmes dedicated to the care of the environment are also free. In fact the investments for a proactive environmental programme not only do not exceed the costs of a non-compliance with law (short-term problem) or liability costs (medium/long-term problem), but must be seen as an opportunity to increase profits, improve the company image and anticipate future legislation (Curkovic and Srouf, 2007).

4.4.3 Supplier partnership

The impact on the end product depends highly on the suppliers of materials and equipment. For this reason suppliers are being requested to supply a material safety data sheet with specific reference to data on safety and data relevant to the impact on the environment, and also on environment impact assessment for new equipment (Curkovic and Srouf, 2007).

4.4.4 Audits

In addition to the quality audit, widely performed by customers vis-à-vis their suppliers and according to the European Regulation EN 29000, the environmental audit has the scope of improving the environmental impact caused by industrial activities. Environmental Management and audit Scheme (EMAS), the European Regulation, requires the: (i) introduction and implementation by industries of policies, programmes an environmental management systems; (ii) systematic assessment of the efficiency of these factors; and (iii) advertising the environment efficiency (Vais *et al.*, 2006).

One can argue that the analogies, in a quality oriented company, with these links between TQM and EM, it is not necessary to convince anyone to operate in a "greener" manner because each person is already convinced of his/her own role in achieving better quality. This could be applied in an individual, employees and companies' levels.

4.4.5 Comparisons between ISO 14000 and ISO 9000

ISO 14000 and ISO 9000 were established to operate as a part of the overall management system which includes the organisational structure, planning activities, responsibilities, practices, procedures, processes and resources for developing, implementing, achieving, reviewing and maintaining a company's environmental policy (Orofi *et al.*, 2002). BS EN ISO 9000:2000 standards are a formal set of Quality Management System (QMS) (Watson and Griffith, 2004:242). QMS embraces all areas of the organisation: marketing, contract acceptance, product design, production, delivery, service, financial and administration (Love and Li, 2000).

Today business environment is such that managers must strive for competitive advantages to hold on their market share. Price is no longer the major determining factor in customer choice; price has been replaced by quality (Watson and Griffith, 2004:242). BS EN ISO 14000 and BS EN ISO 9000 are unique in not dealing with a particular product but rather assisting the system as a whole. BS EN ISO 14000 provides organisations the framework for EMS (Lwrence *et al.*, 1998). Benefits from ISO 14000 implementation include: (a) reduced operating costs; increased access to markets; (b) demonstrated compliance with regulations; improved environmental performance; (c)improved customer trust and satisfaction; enhanced corporate image and credibility; and (d) employee involvement and education; and potential impact on world trade to allow competition on an equal basis.

ISO 9000 was the template for developing ISO 14000. Table 4-5 presents similarities and differences between the ISO 9000 and ISO 14000 series. In terms of resource savings and improvement in environmental responsibility, there is value in integrating the two standards. The ISO 9000 standards strive to assure consistency of products and services delivered through a structured and systematic approach to their production. When similar approach is applied to environmental issues, reduction in both actual and perceived environmental and regulatory liabilities could be realised.

Table 4-5

Table 4-5: ISO 14000 Vs ISO 9000

Features	ISO 9000 series	ISO 14000 series
Similarities Components	Both contain standards which are advisory or guidance	

	documents, and standards to which a business may elect to become certified: one in ISO 14000 and three in ISO 9000	
Policies and objectives	Policies and objectives Both require clearly stated policies and objectives and well-defined assignments of responsibility	
Training	Training Both series require employees to be trained on what is expected of them and how those expectations are to be met	
Monitoring	Monitoring and measuring activities and performance are a requirement of both standards	
Review	Review Management and audit reviews are required by both. Each requires that results be monitored and recorded so that an outside party can observe and report that the system is working	
Documentation	Documentation Both standards require documentation that all programmed and system requirements are in place	
Performance specification	Performance Neither standard specifies the performance results	
<u>Differences</u> **Impetus**	Impetus for development was the desire to improve and maintain the consistency of the quality of products internationally.	Development was driven by the explosion of environmental laws and regulations worldwide.
Companies' motivation	Companies became interested from a desire to protect and expand their market position.	Firms sought to ease the problem of conforming to laws and regulations and improving market place acceptance.
Target audience	Purpose of compliance is focused—to demonstrate to customers that the registrant is a quality producer	Audience for certification includes customers, government, employees, shareholders, lenders,

		investors etc.
Focus	Concentrates on what it takes to consistently produce a quality product or service	Focuses on what is necessary to achieve continuing improvement in environmental performance.
Continual improvement	Continual improvement is an implicit requirement	Continual improvement is an explicit requirement
Supplier involvement	To maintain the quality chain, a certified company must use certified suppliers.	Supplier condition is not present in ISO 14000.

(Source: Orofi *et al.*, 2002)

Organisations which link ISO 9000 and ISO 14000 have the opportunity to develop a consistent management system which is cost-effective and represents a higher chance of implementation success. There is a synergy between ISO 9000 and ISO 14000 in terms of multitask management of QMS and EMS. The areas most adaptable to this type of integration include: document and data control; process control; training; and internal auditing (Curkovic and Sroufe, 2007).

The main benefit from merging quality systems with environmental systems are: saving time; cost saving from combined audits; possibility of multi-tasking, saving manpower and reducing management's span of control; and reduction in paperwork and operating costs.

4.5 From TQM to TQEM

Many calls attention to an expanded focus for TQM to include the business environmental impact can be found in the literature (Sroufe and Curkovic, 2007a; Whiteman and Haupt, 2004). Providing an exploratory discussion, that integrates environmental legislation, public concerns and consumer requirements with traditional operations management thinking, supports the view of the potential role of TQM in developing synergies between operational performance and environmental excellence (Orofi *et al.*, 2002).

It is noticed from the previous section that TQM does not in itself decide the technical or commercial specification of a product, but establishes disciplines that assist in the consistent attainment of quality requirements (Love *et al.*, 2000). An environmental management system (EMS) requires in the main that an organisation identifies and registers its environmental effects, while promoting continual environmental improvement, but does not need to comment on overall environmental performance. TQEM focuses on the organisational structure, procedures, processes and resources needed to implement quality management, when these elements are compromised; they define how the organisation works, and how quality is managed (Orofi *et al.*, 2002).

The Global Environmental Management Initiative (GEMI) created the TQEM model in an attempt to align Environmental Management (EM) and TQM (Love *et al.*. 2000). TQEM is the integration of a comprehensive lifecycle approach to TQM and EM which includes; 1) customer identification and satisfaction; 2) continuous improvement; 3) a proactive approach to problem solving; and 4) a systems approach to business, explicitly including the natural environment.

In 1990, Global Environmental Management Initiative (GEMI) coin the term Total Quality Environmental Management (TQEM) when few in the global business community recognized or understood the meaning of those words. TQM was developed at the same time as EM issues began to emerge. The up-to-date concept of total quality environmental management (TQEM) reflects the parallelism between quality and environmental problems. In the vision of a TQM-oriented organisation in which, by striving for continuous improvement, quality is deployed to everybody, the analogy with the environmental policy is demonstrated by the fact that every person in the firm is already convinced of his/her own role in this domain (Whiteman and Haupt, 2004).

To conclude, it is agreed that quality improvement approaches can be applied in the environmental context. Although environmental issues can occasionally negatively impact an organization's core business, most environmental programs can lead to both improved profitability and increased social responsibility. Hence, examples from the manufacturing sector show that TQEM is a time-prove techniques that have helped reduce quality costs and improve market share can provide similar results when applied to many environmental problems. Techniques based on TQEM are already being used by many organizations. This concept emphasizes on four basic elements: customer identification, continuous improvement, do the job right the first time and a systems approach to work.

4.6 TQEM Integration

This section highlights TQEM criteria of integration within a sustainable context, adapted from Hassan (2006) as follows;

- Strategic management: The corporate mission, vision, culture etc. are evaluated against the environmental goals in order to identify conflicts and synergy. Additionally, proactive and reactive strategy plan takes into account the sustainability planning. The strategic attitude concerning environmental management is the subject for creating an environmental management system.

- Economic management: This includes; Evaluating investments in cleaner technology; Encouraging and performing green accounts; and Balancing between economy and environmental sustainable design according EMS. The LCCA tool can be helpful in this respect.

- Supply chain management: Appropriate life cycle assessments of a building product requires an access to a large amount of information from both ends of the supply chain, which demands new types of co-operation and integration between many partners in the supply chain. Furthermore, the development of new and environmentally improved products is an important activity in environmental management and it requires an increased focus on co-operation between partners in the supply chain.

- Production management: Investments in cleaner and sustainable technology, and optimisation of building production processes from an environmental point of view is becoming increasingly important, and environmental consideration regarding production processes should be an important part of an effective environmental management system.

- Product management: Introduction of LCA and LCCA in the design phase of building products may be considered as one of the most important aspects of environmental management. Moreover, the corporate environmental profile and the environmental aspects of building products are also becoming an important element in marketing since environmental information e.g. environmental reports can be included in a proper marketing strategy.

- Health and safety management: From construction view point, many construction companies have a well functioning health and safety organisation. Furthermore, health and safety issues should be integrated and/or co-ordinated with environmental management activities.

- Energy management: Many building companies have effective energy management. The experiences from this work can be used for creating procedures for an effective environmental management system. Moreover, the concept learning organisation should be benefit from these experience inputs.

- Information management: Valid information regarding the environmental sustainable performance is essential to efficient environmental/sustainable management. The corporate information system needs to be adjusted according to the requirements of environmental management.

- Quality management: Commonalties between requirements specification standards, methods, principles and tools for quality management and environmental management are important. It is vital to combined procedures for quality and environmental management, as will be discussed in later on. Additionally; adapting the principle of continuous improvement to achieve the sustainability in view of the criteria mentioned previously.

TQEM could be integrated in the UK construction companies into the same management areas presented above. The essence of the process is to identify and eliminate any waste, which consumes resources, but creates no value: transport, inventory, motion, waiting, overproduction and defects, in short “do more with less and less”—less resources, less effort, less equipment, less time, while becoming closer to providing what costumers actually want.

To become TQEM company, a company has to focus on TQEM’s core issues for the entire project. This study will address TQEM integration on both corporate and project levels. The corporate-level TQEM represents the vertical integration in terms of the cultural and business aspects. The project-level TQEM includes construction performance and procurement, in other words the horizontal integration throughout the supply chain and the rest of the points mentioned above. This is explained further in Chapter Nine. The following section will highlight different interpretations on TQEM integration.

4.7 TQEM Frameworks

The results of the literature review show that the move to adoption of environmental business practices. TQEM has been viewed from a perspective heavily influenced by either normative or legal considerations by Klassen (2000a, b), and Curkovic (2003), with some evidence that TQEM can be motivated by the potential for competitive advantage and improved public relations by Khanna and Anton (2002). Curkovic and Sroufe (2007) found that for most companies, compliance is seen as an adequate position to assume. With compliance, the firm does only what is necessary to meet the letter of the law. It is a reactive position that means environmental problems are corrected once they have been created. Many have claimed this is relatively ineffective because it does not attack the causal factors, merely the symptoms (Curkovic and Sroufe, 2007; Klassen, 2000a). It is also a potentially dangerous position given the retroactive and dynamic nature of many Laws in the construction industry. That is, what may be in compliance today may be considered out-of-compliance tomorrow. As a result, the firm may find itself always spending to bring itself into compliance with regulations that are continuously becoming more stringent.

According to GEMI's 'TQEM Primer, there are four basic elements for developing TQEM framework are:

- Customer identification: in TQEM, environmental quality is determined by customer preferences. Buyers, the local community, environmental groups and the general public are considered external customers, while a company's employees represent the internal customer group.

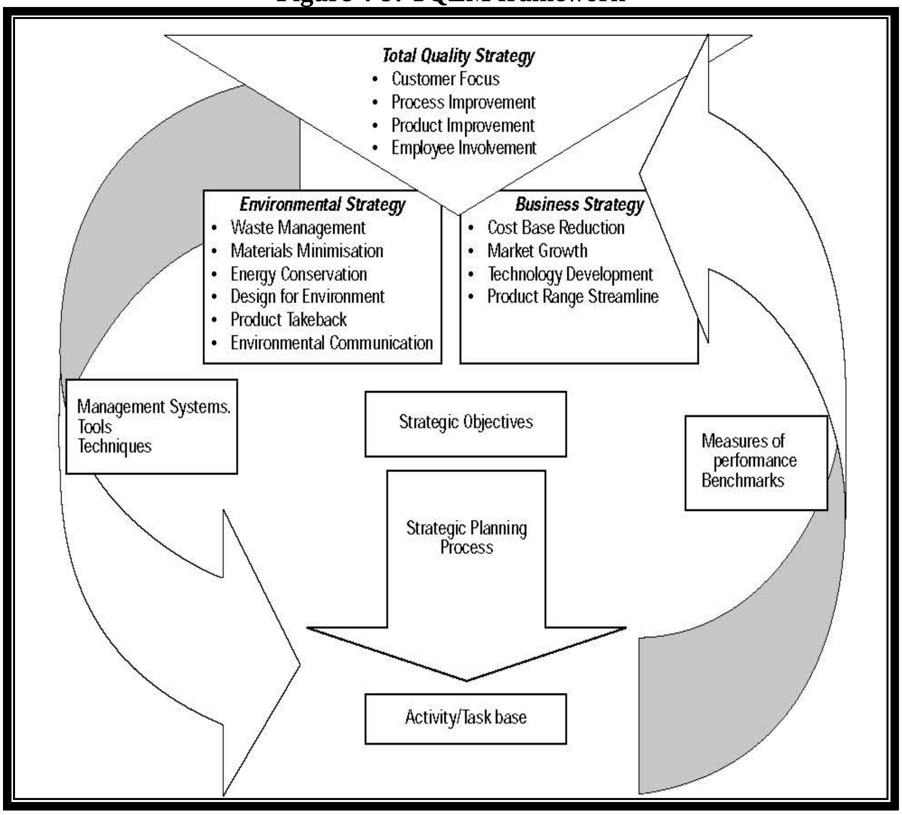
- Continuous improvement: a company's management and employees should work systematically towards the improvement of environmental performance. Company-wide employee involvement in TQEM is a key to success.

- Doing the job right first time: TQEM supports the elimination of environmental risks. Employees should seek to identify and eliminate potential environmental problems.

- It is important to design all components of the TQEM system so that they function together and support each other in achieving desired goals.

Figure 4-9, presented by Lawrence, 1998, focus on EM operational activities become focused on achieving one strategy, the TQM strategy. The framework defining exactly what TQM means to the organisation and how it will be achieved. Achievement of individual strategies, for example environmental strategy, is measured against TQM strategy. This general approach gives the focus rather than how to achieve those given objectives.

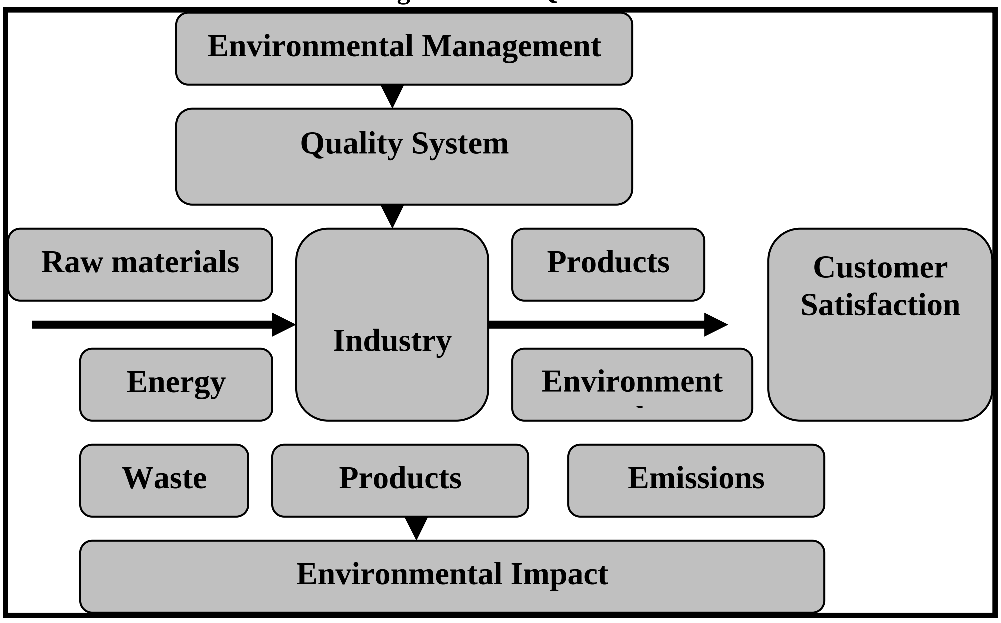
Figure 4-9: TQEM framework



(Source: Lawrence *et al.*, 1998)

Figure 4-10, by Borri and Boccalettti (1995), reflects the existing parallelism between quality and environmental problems. The authors tried to develop a proactive, model which is characterised with embedding the environmental objectives at all levels of the hierarchy thus widening their competence on the horizontal supply chain stages. However, this approach appears to be very general with no clear differentiation between the vertical and the hierarchical integration levels. TQEM framework for construction industry should comprise elements from TQM and EM with relevance to the UK construction industry characteristics and needs.

Figure 4-10: TQEM framework



(Source: Borri *et al.*, 1995)

There are key shared factors between the above TQEM frameworks. A TQEM framework should begin with commitment to satisfying stakeholders. Knowing what they need and expect drives the development of the system that improve performance and better satisfy their needs. High-level of senior management commitments is essential if organisation is to commit the resources needed for excellent performance, and create consistency throughout the organisation. Once commitment has been obtained, the organisation then begins to prioritize TQEM integration TQEM i.e. gathering and analysing comprehensive information pertinent to its environmental needs. Priorities are then channelled into strategic planning where plans and objectives are created. Also, people involvement (knowledge, skills, commitment and teamwork), techniques and standards (QMS, EMS), and performance measurement indicators are needed for implementation.

In this sense, TQEM could move the organisation ever closer to its ultimate goal of achieving performance improvement towards sustainability. Thus, there are a few problems associated with TQEM implementation which are highlighted in the following section.

4.8 Deficiencies in Past TQEM Literature

This section highlights some areas overlooked by past TQEM studies and discusses how the present study will address these deficiencies. The following are some of the most important paradoxes and problems associated with the development and implementation of TQEM:

- Klassen (2000a) and Hanna *et al.* (2000) claim that top management must be willing to accept and champion corporate wide developments if TQEM is to become widespread. However, when dealing with TQEM, some research has shown there is a strong bias in favour of ignorance at the highest levels of the firm (Curkovic and Sroufe, 2007). The shortcoming of not developing a formal TQEM framework for identifying and prioritizing client requirements ensures that quality and environmental standards are clearly defined at an early contract stage will be addressed by this study. This will help construction clients to clarify their vision of the facility to be constructed through; the encapsulation of the client's requirements, formulating design solutions which satisfy all client needs, cost effectiveness, and high quality and environmental standards.

- Hanna (2000) shows that in the short run, implementing TQEM often causes costs to rise. For that shortcoming, the meaning of TQEM Total Cost Assessment was developed by Curkovic and Sroufe (2007). What remains to be studied is adapting these methodologies to the construction industry. This may require some changes in the tendering procedure for novated D&B projects. These changes are not expected to affect the cost of tendering for D&B projects as the overall cost of construction projects is expected to be reduced due to the significant cost savings that will result from the drastic reduction in the number of late design changes, the exploitation of the project team's expertise early in the design process, and minimization of delays, claims and disputes.

- Sroufe (2003) indicated that being environmentally responsible ultimately makes a company more efficient and more competitive. However, there are many reported cases of environmentally responsible investments which have resulted in negative returns (Klassen and Angell, 1999). What remains to be studied is a new approach that ensures the quality and environment of the end product since the client's requirements are well defined and can be used to check compliance and performance. The clear definition of client requirements at an early stage results in a reduction in uncertainty for all parties to a given construction project. The proposed approach of TQEM would also enable construction clients to move away from 'lowest cost' as the principal criterion for the award of construction contracts.

- Angell and Klassen (1999) and Ahmed (2001) support the notion that ideally, the most appropriate place for considering TQEM issues is in the design phase since the amount of waste generated is a direct consequence of decisions made during design. Hence, Sroufe (2003) claims that there is a lack of appropriate management framework for capturing the environmental impact of designs. This shortcoming has caused large amount of rework and duplication inherent in the conventional project performance. Yet, this can be dispensed with shortening lead times and reducing cost. Delays, disputes and claims which often result from existing procedures can be reduced saving time and money over TQEM.

- There is evidence by Curkovic (2003) that managers need frameworks or guidelines which they can use to better understand what TQEM is and its components. However, a great deal of the information surrounding TQEM is either legally based or derived from anecdotal stories and case studies as pointed out by (Curkovic and Sroufe, 2007). This study will address this shortcoming by focusing on managers' opinions and TQEM corporative culture. This can be achieved by capturing the relationship between all the parties involved in a project realization. These groups dynamics should be enhanced under the new TQEM approach as there may be an obviation of the disharmony caused by the introduction of novated consultants at the post-tender stage. With TQEM, better informed design decisions can be made thereby narrowing the gaps between design and performance knowledge, and between incurred and committed costs at the design stage. TQEM management-based approach allows for improved communication and co-ordination between members of the project team.

Finally, and the focus of this study, UK construction organisations' managers have difficulty implementing and managing TQEM because of the lack of appropriate framework. In order for TQEM to be given serious consideration by a firm, it has been suggested by Curkovic and Sroufe, 2007, that a process is required for integrating TQEM by appropriately including business and processes. However, there appears to be a lack of easy-to-use TQEM framework.

4.9 Summary

Calls from the literature draw the attention to the importance of an expanded focus of TQM to include the environmental impact. Just as the concept of TQM forced a change in the economic paradigms of quality and customer satisfaction, the concept of TQEM have overcome the traditional economic assumption that EM reduces productivity.

The spiralling demand for more environment and sustainability evolution, in particular increasingly stringent regulation, mirrors the evolution of quality management within construction (Griffith *et al.*, 2000). In fact strategic EM, which means integrating environment management at all levels from the company strategy, continuous improvement process, to ecoefficiency, coincides with that TQM.

A range of EM, TQM, TQEM tools and frameworks were reviewed in this chapter to explore the extent to which they where able to provide a robust process to enable assessment of overall quality and environmental issues. Of these approaches, the available frameworks have been recognized as extremely information intensive, conceptual, difficult to implement, somewhat subjective and difficult to defend. Many studies conducted on EM and TQM and fewer on TQEM. Research in this area is generally considered to be divided into three broad groups; (1) The passive model is characteristic to those organisations that resist change and consider the environmental issues only as a cost, overlooking the possibility of new opportunities; (2) The active model is characteristic to those organisations that work just to comply with the regulations; and (3) The proactive model is characteristic to those industries which have embedded their environmental objectives at all levels of the hierarchy (widening their competences and responsibilities and changing their mission accordingly). In the third approach, when the environment becomes a key issue, its pervasiveness at all levels derives from the company's strategies and the continuous improvement process of the eco-efficiency coincides with that of TQM.

The discussed TQEM frameworks are derived from the same premise that EM needs to be incorporate into TQM historical approach. The basic elements of TQEM framework should include a strong stakeholders focus, a high level of senior management commitment to meeting their needs and expectations, and a "tool kit" that includes teamwork empowerment, continuous improvement, root cause analysis, and a prevention approach. TQEM for Novated D&B contractors could benefit from several EM and TQM approaches such as; EIA (project-by-project based approach to minimising the effects of construction on the environment), EMS (company-based approach to managing the responsibilities in terms of environmental legislation across all the organisation activities), EMP (operational-based approach that aims to comply with the environmental legislation as a minimum benchmark). EMSs (i.e. ISO 14001, EMAS, BS 8555) are a standards-based approach similar to QMSs (i.e. ISO 9000 series), which may in the construction industry will be familiar with already and often the procedures that are in place to manage quality can be adapted for managing environmental issues (Watson *et al.*, 2008:268).

Principal contractors with any existing QMSs or EMSs may consider developing a TQEM that integrates EM and TQM and concludes a selection of tools, programs from these systems. Consequently, the effective management of both corporate and project aspects is dependent upon the synthesis of many interdisciplinary elements and resources. For performance improvement, the functional interaction of the project and corporate levels is necessary for successful delivery of a project and for contributing to the well-being of the organisation. The ultimate aim of any project is the establishment of the client's objectives and the design of the project organisation structure. To put this discussion into a wider context, TQEM role towards sustainability is explained in the following chapter.

CHAPTER FIVE

SUSTAINABILITY AND THE EMPLOYMENT OF TQEM IN THE UK CONSTRUCTION INDUSTRY

CHAPTER FIVE: SUSTAINABILITY AND THE EMPLOYMENT OF TQEM IN THE UK CONSTRUCTION INDUSTRY

5.1 Introduction

As one of the largest industrial sectors in the UK today, the importance of sustainability for construction cannot be overstated. Companies within the UK property sector have managed to evade the sustainability agenda for quite some time. The property sector needs to change towards corporate sustainability (Sustainable Construction Task Group, 2007). Construction contributes to Sustainable Development (SD) along the entire chain of modern production and consumption, including extracting and developing natural resources, processing and modifying resources, designing and building infrastructure, meeting the needs of consumers, recovering and reusing resources, and producing and distributing energy (WFEO, 2002). This chapter will introduce the concept of sustainability and TQEM role towards sustainable development. It will outline the environmental impacts resulting from construction activities and will consider how TQEM may reduce these impacts.

Sustainable development is a multidimensional concept as it combines economy, environment, quality of life and social quality. Many concentrate on its three dimensions of economy, ecology and social quality. The preceding sketch of the economic theory of sustainability has mainly been discussed at the level of a nation (Pearce, 2006). Indeed, this is how the literature has developed (Hamilton *et al.*, 2005). But the exercise of managing sustainability in the construction industry can nonetheless be conducted.

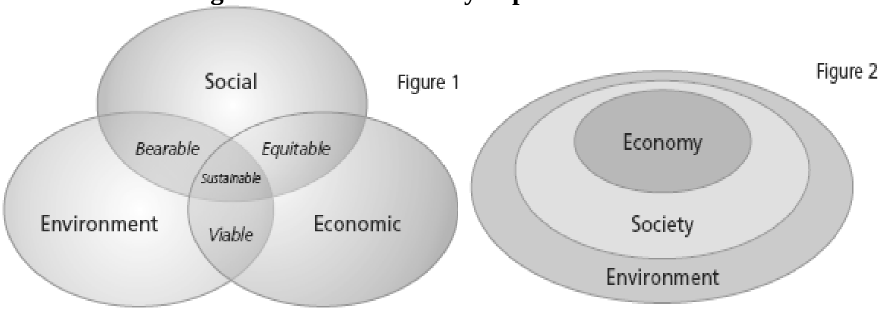
A few studies address the need to harness multiple management systems towards sustainability. Pearce (2006) stated that although sustainability application at the level of the nation is well-established, its application at the construction sector and at the firm level is far less tried. Watson (2008) provided a systematic review of all building sustainability aspects. Hassan (2006) presented an integrated management approach to design sustainable buildings based on a number of criteria linking the building to its planning, technical and physical environment. Karapetrovic and Willbom (1998) studied strategies for integrating ISO 9001 and ISO 14001 towards sustainability. Bossel (1999), made an overview of sustainable development theories and indicators from a systems analysis point of view. A research carried out by the BRE centre for sustainable construction, published in a paper titled *Putting a Price on Sustainability in 2005,* found that across a range of building types, 1–4% increase in capital costs saving were achieved in the region of between 3% and 26% of energy costs and 10% and 71% of water costs. This study suggests that the perception that sustainable design and construction incur substantial additional costs is clearly wrong. The Stern review (2006) examined the economics of climate change and found that taking action now to reduce the level of emissions of green house gases is the much cheaper option than trying to deal with resulting problems caused by global warming.

This study advances building sustainability theory by developing a synergic management approach that applies key concepts of quality and environmental methodologies. The sustainability criteria and indicators are presented and defined in this chapter. Also, the role of TQM, EM and TQEM towards sustainable development is explained, and finally the research framework is discussed.

5.2 Sustainable Development Triple Bottom Line, Opportunities and Threats

Sustainability has been defined as the goal of sustainable development. A widely-used and internationally accepted definition of sustainable development is "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (Brundtland, 1987). In the UK, the Government offers the following interpretation of sustainable development: sustainable development is commonly conceptualized as having three dimensions: environmental, social and economic. These dimensions are often symbolised as overlapping circles, and have been characterised by business in particular as the 'triple bottom line' (Figure 5-1).

Figure 5-1: Sustainability triple bottom lines



(Source: ICE, 2007)

However, other sustainable development proponents have placed the social and economic 'circles' within a larger environmental circle, to symbolise the extent to which environmental capacity provides an overall constraint on development. With more than 200 definitions that can be found for sustainable development, there is much debate as to its precise definition (Parkin, 2003). Thus, the common view of the main components of sustainability involves the integration of economic, environmental and social elements, and minimising the trade-offs that have to be made between those elements (Defra, 2005). More importantly, a sustainability-driven approach to civil engineering leads to adoption of some key objectives in practice (ICE, 2007):

- dramatically reduce the environmental impact
- dramatically improve the environmental quality
- maximise the utilisation of materials and their reuse
- maximise appropriate use of secondary and recycled materials
- minimise waste in design, construction and use
- minimise energy and water use
- minimise pollution from all our activities
- focus on increasing peoples' quality of life through good urban design
- ensuring respect for people; towards the workforce and the surrounding community.

This should be reflected in everything from health and safety to site and welfare conditions, providing training opportunities, promoting equality and work-life balance and in encouraging job satisfaction. Other related concepts used throughout the study are defined below.

- Sustainable communities operate at different scales, global, national, urban and rural. They are places where people want to live and work, now and in the future. They meet the diverse needs of existing and future residents, are sensitive to their environment, and contribute to a high quality of life. They are safe and inclusive, aesthetically pleasing, well planned, built and run, and offer equality of opportunity and good services for all (Communities and Local Government, 2007).

- Sustainable construction. This subset of sustainable development refers to the creation, maintenance and operation of infrastructure and buildings that shape communities in a way that sustains the environment, generates long term wealth and enhances the quality of life (Construction Skills, 2007).

- Corporate responsibility is the ethical responsibility of organisations to deliver sustainable development. Essentially it is about how business takes account of its economic, social and environmental impacts in the way it operates – maximising the benefits and minimising the downsides.

There is an increasing body of evidence that companies that have taken a more sustainable strategic approach have achieved positive outcomes (Chater, 2002). The nature of these benefits varies for different organisations and is dependent on their industry, size, strategy and stage of development. These benefits, according to SIGMA guideline (2003) can be classified as follows: Improved operational efficiency; enhanced brand value and reputation, customer attraction and retention, enhanced human and intellectual capital, improved management of risk, attracting and retaining talented staff, preservation of license to operate, promoting and increasing innovation, improved access to capital, building and sustaining shareholder value, generating increased revenues, and identification of new opportunities.

Sustainable Development is typically defined as 'meeting the needs of today without compromising the needs of future generations'. It is "the capacity for continuance into the long term" (The Brundtland Report 1987: Cited by Climate change report, 2006).

Thus, the view that sustainable development is the key factor of shifting business into new dimensions of competitive advantages is widely approved *(Strong and Hemphill, 2006; Elgar *et al.*, 2002).

In practice, the concept of business sustainable development has received growing recognition, but it is a new idea for many business organisations. For most, the concept remains abstract and theoretical (A strategy for sustainable development for the UK, 2005). In general, protecting business organizations' capital base is a well-accepted business principle. Yet, organizations do not generally recognize the possibility of extending this notion to the world's natural and human resources (WBCSD, 2004). Thus, businesses are at different stages on the way towards sustainable development. Many business organizations have started with pollution prevention and some health and safety issues. Others have addressed all their contributions to society's economic, environmental and social objectives in an integrated way towards a more strategic approach (A strategy for sustainable development for the UK, 2005).

If sustainable development is to achieve its potential, it must be integrated into the organisations planning and measurement systems. And for that to happen, this concept must be articulated in terms that are familiar to business leaders (A strategy for sustainable development for the UK, 2005). UK government's sustainable development strategy identifies four objectives to be met, namely: social progress which recognizes the needs of everyone, effective protection of the environment, prudent use of natural resources, and maintenance of high and stable levels of economic growth and employment.

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*The Stern Review (2007), on the economics of climate change, outlined the costs of inaction in addressing the problem of climate change. It forecast that any approach for construction improvement should tackle sustainability. There are sound reasons for pursuing sustainable development. There are already examples where a sustainable development approach makes the industry more competitive, more resilient to shocks, more flexible in a fast-changing world, more unified in purpose, more likely to attract and hold customers and the best employees, and more at ease with regulators, banks, insurers, and financial markets.

This section has highlighted sustainable development importance, opportunities and threats. The current construction approach to development is unsustainable, with overexploiting resources and creating pollution, changing habitats and driving species to extinction. Unsustainable development also creates social problems which are exacerbated by the inequalities in health, wealth, education and employment which accompany it. It is now almost universally accepted that global climate change is a reality and that human emissions of greenhouse gases are a contributory factor. It is important not to overstate the potential of these benefits accruing across the whole industry, or to understate that the task ahead is adding value to the construction through sustainability. Therefore the following section addresses the role of construction towards achieving sustainable development.

5.3 Outline of Sustainable Management of Buildings

Having stated the importance of addressing sustainable development opportunities and threats, this section outlines the role of the construction sector towards sustainability. The building industry plays a crucial role in creating the infrastructure needed for modern life around the world. Practitioners in the civil engineering sector apply knowledge and experience to create projects that meet human needs and clean up environmental problems. As a result, the way in which the civil engineering sector works has significant impact on progress toward sustainability.

The case of sustainable buildings from a variety of areas such as sensor systems, computation, materials, biometrics, energy management and security can be adapted and adjusted according to the occupants. Integrated sensor systems can measure indoor and outdoor environmental conditions and operate as part of a complex system that can provide maximum performance and comfort (Hassan, 2006). Embedded sensors are used to monitor the occupants' daily activities as well as the energy consumption. As indicated earlier, a major aspect of sustainability is energy consumption. Carbon dioxide from fossil fuel power stations is high, whereas that from renewable resources such as solar power, wind power and biomass is very low. The economics of solar photovoltaic systems are becoming increasingly attractive so that by 2010 they will be a viable alternative in many situations (NIO, 2008).

It is expected that buildings will be largely shaped by value for money, water conservation, occupant well-being, health and productivity, low emissions to environment, renewable energy and energy efficiency. As these factors are the core aspects of sustainability, it is apparent that intelligent buildings are a feasible step towards designing and constructing sustainable buildings. Recent studies (Nash *et al.*, 2006) have shown that the attitudes and behaviour of owners and occupants of buildings have a significant impact on the energy consumption and hence CO2 emissions associated with the building in use.

The embedded sensor technology retrofitted to existing buildings can be used to monitor energy consumption and explicitly provide information on the performance of buildings, which stimulates changes in occupant behaviour to consume less energy. It has been estimated that the largest reduction in energy consumption can be achieved between similarly insulated buildings by changing the behaviour patterns of the building users (Hassan, 2006). Accordingly, the TQEM techniques and systems approach may be integrated in a synergic manner for designing and achieving building sustainability. Sustainable buildings may have greater capital costs but can have lower running costs (INO, 2008). Analysis conducted by the Building Research Establishment (BRE, 2005) aimed to challenge the assumption that more sustainable design and construction incurs substantial additional costs. By identifying the costs associated with achieving different BREEAM ratings for a variety of building types, they showed that significant improvements can be achieved for relatively little additional expense.

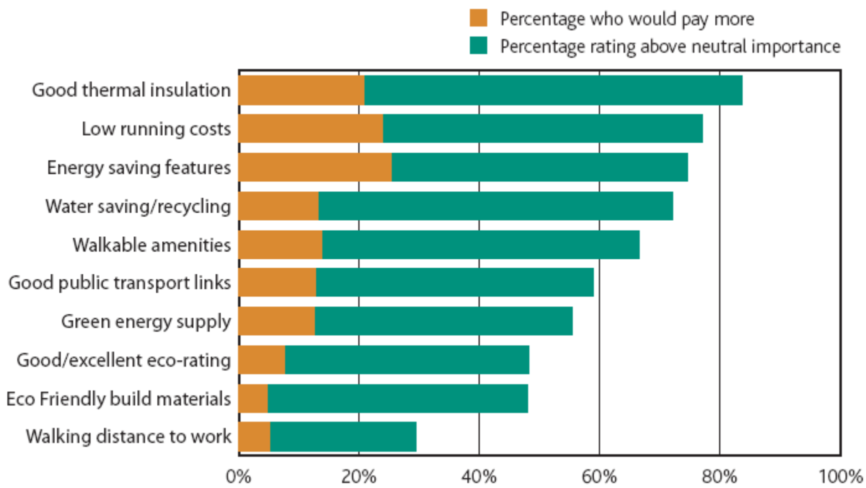
While the BRE message reinforces the perception that building sustainability costs more, it is important to bear in mind that the operational costs of a building are typically many times the cost of building it. BRE, however, did not evaluate in detail the whole life costs and benefits of building to higher environmental standards. It pointed out the fact that sustainable building options would result in significant reductions in the costs of water and energy.

To sum up, improving sustainable construction is a government-wide target and an action should be taken to address the serious and widespread failure to achieve the objectives set. An effective integration to building sustainability requires enhancing the management tools within a corporate strategic approach, which is proactive with respect to sustainable issues. Integrating TQEM approach that leads to designing sustainable building can possibly achieve the corporate business excellence in a construction company level.

5.4 Phases Involved in the Building Sustainable Management

Consider now the life cycle of building products, the indicators of sustainable construction may be taken into account through planning, architecture, construction operations, building reuse and adaptation, and finally disposal (Hassan, 2006). According to the performance improvement mechanisms explained in chapter three, the sustainability of building may be viewed as a macro process of six phases that covers the life cycle of the building: resource extraction, manufacturing, on-site construction, occupancy/maintenance, demolition, and recycling/reuse/disposal (Barrett, 2008b). Figure 5-2 illustrates the main links between building and environmental and sustainability issues. These phases are supposedly reacting with each other. This implies that the sustainability must be integrated on all these phases provided that the output of each phase can be considered an input to the following one (Green *et al.*, 2007). Consequently, as a process, the sustainability of building must be identified, managed and improved.

Figure 5-2: Links between building and environment and sustainability



(Source: Callcutt review, 2007)

Additionally, the sustainability process in this case may be defined as a network of these phases that interact with each other to accomplish these objectives. It is noticeable that the research in this area did not link the mentioned sustainability phases with the parties responsible for each phase. This research covers the phases under the contractor responsibility. With this in mind, TQEM methodology applied to achieve sustainable buildings can now be planned and investigated, as discussed below.

5.5 Employment of TQEM Methodology towards Sustainability

A synergic approach can be obtained by integrating several methodologies (Hassan, 2006). Chapter four pointed out TQEM methodology and several tools, techniques, measures and systems with regard to EM and TQM. Harnessing EM and TQM methodologies by defining their tasks and integrating them on different levels within the lifespan of construction's business and processes can increase the necessary competence for designing for sustainability (Green *et al.*, 2007). This section points out the role of TQM and EM methodologies in construction sustainability. The discussion highlights this study suggested for the employment of TQEM methodology towards sustainability.

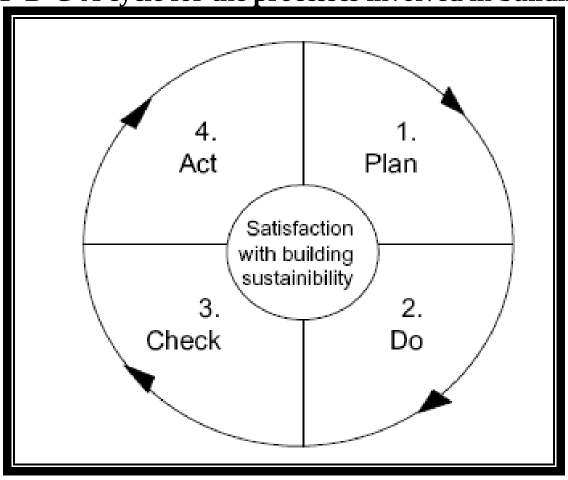
5.5.1 TQM role towards sustainability

The TQEM may be identified as two different concepts of TQM and EM having a common ground or application. Quality is defined by ISO 8402 as the totality of characteristics of an entity that bear on its ability to satisfy stated needs or implied needs. This global definition, however, does not state clearly what constitutes quality of systems. For the case of sustainable buildings, quality is a dynamic state associated with the processes, environment and social aspects. The main elements of quality should include the following features: Conformance to society specifications, conformance to legal and statuary requirements, meeting or exceeding the anticipated wishes of the society as a customer, superiority over competitors, and planning for sustainability (Hassan, 2006).

The fifth point is a necessary feature since the sustainability part of any building design and construction should be included. For the case of building sustainability, TQEM is achieved when the following elements are present: Society focus (internal and external), focusing on quality, scientific approach to decision making, long term commitment, teamwork, continual process improvement, education and training, freedom through control, unity of purpose, and peoples' involvement and employment (Kibert, 2008).

To mandate the role of TQEM for sustainable buildings, this study suggests continuous improvement for all the actions involved in the processes of building sustainability. For example, adopting Deming concepts (1982) i.e., P-D-C-A cycle, as shown in the following figure. Subsequently, in the plan part of the cycle, the following features are to be considered: Understand the gap between the criteria of sustainable buildings, as mentioned previously and the actual situation in the project, set priorities for closing gaps, and develop an action plan to close the gaps (Hassan, 2006).

Figure 5-3: The P-D-C-A cycle for the processes involved in building sustainability



(Source: Hassan, 2006).

As Figure 5-3 illustrates, the P-D-C-A process is about the following stages:

- In the Do part, the features may be taken as: Implement eventual changes, and collect data to determine if gaps are closing.
- In the Check part: Observe the effects of the change or test. TQM tools can be applied such as cause and effect diagram, flow chart, etc. and pinpoint problems.
- The Act part may include: Studying the results and redesign the components of the building to reflect learning, change standards, communicate it broadly, and retrain.

- The last step is constructed by repeating step 1 with knowledge accumulated and step 3 is to repeat step 2 and onward as the figure above illustrates (Hassan, 2006).

Step 4 is constructed by repeating step 1 with knowledge accumulated and step 3 is to repeat step 2 and onward. One of the tools that can help in achieving the above-mentioned elements in the P-D-C-A loop is to analyze the situation with the help of value-focused thinking approach, as will be discussed later. Consequently, a stable sustainable building system is a system whose performance is controlled and predictable. It is obtained by identifying the special causes of a problem and removing them.

The implementation of Quality Assurance (QA), on one hand, will fulfil the requirement for quality (Whiteman and Haupt, 2004; Reed *et al.*, 2000). On the other hand, it could assist all the planned and systematic activities implemented within the quality system and demonstrated as needed to provide adequate confidence that an activity in the sustainable building. According to Hassan (2006), QA activities would include: Controlling design of building components and construction processes, recording on verification of qualification records, identifying of inspection status, and inspection project equipments. This section pointed out the TQM role towards sustainability in construction industry by pointing out the role of two tools of TQM, P-D-C-A and QA. With this in mind, the following section reviews the role of EM in sustainable construction, the role of its main tools.

5.5.2 EM role towards sustainability

There is a wealth of research on integrating EM towards sustainable construction. A survey of the literature points to four major environmental management research streams that relate its role to sustainability in an increasingly focused manner: Sustainable development and industrial ecology, strategy and corporate social performance, and environmental technology and innovation. This research has seeded and advanced much of the current thinking on EM and provides a foundation as the field moves forward towards sustainable development.

5.5.2.1 Sustainable development and industrial ecology

One of the most sweeping catch-phrases in environmental management is ‘sustainable development’. EM processes could serve as an ecosystem in an organisation. This ecosystem allows wastes from one industrial process can serve as the raw materials for another, thereby reducing the impact of industry on the environment (Green *et al.*, 2007). Hassan (2006) outlined the economic and environmental advantages of eco-industrial parks, which are planned sites where firms locate because of their commitments to reduce resource consumption and emissions. Combined, these concepts point to systemic connections between the natural environment and operations decisions across organisations.

5.5.2.2 Corporate strategy and social performance

Early research in business strategy proposed that production processes be used to enhance total socioeconomic welfare, and that resources be utilized for broad social ends, not the narrow self-interests of the firm (Welford, 2002). This led to research that measured environmental impact as one key indicator of corporate social performance (Hassan, 2006). The anther identified four management values: economic, ethical, legal, and discretionary.

Those factors are seen as drivers influencing the approach adopted by operations managers on environmental issues. Other researchers posited an organisation's orientation toward environmental management either as a choice along a strategic spectrum, ranging from reactive to proactive models discussed in chapter four. Strategic, firm-specific resources related to proactive environmental management includes: continuous improvement, stakeholder management, the deployment of physical assets and technology, organisational culture, inter functional coordination, and intangible resources i.e. appeal to green customer segments and political acumen (Hart, 1995). Thus, two dominant approaches to environmental management emerge: proactive pollution prevention, which relies on strategic resources and thereby can deliver sustainable competitive advantage, and reactive pollution control, which cannot impart competitive advantage (Hassan, 2006).

5.5.2.3 Environmental management and innovation

Technological innovation has generally been accepted as one important basis for substantive, sustained, long-term improvements in environmental performance (Hart, 1995; Welford, 2002; Hassan, 2006) defined environmental technologies as any production equipment, methods, practices, product designs and delivery systems that limit or reduce the negative impacts of products or services on the natural environment. Environmental technologies can drive down operating costs, create competitive advantages with unique environmental strategies, reduce long-term risks, and regulations (Porter and van der Linde, 1995). The authors argue that being a first-mover for environmental technologies can positively impact firm-level financial performance. Barriers to further development and implementation include managerial attitudes, organisational structures, and perceptions of risk (Hassan, 2006).

Finally, a growing body of research has dramatically shifted attention away from end-of-pipe environmental technologies to pollution prevention and cleaner technologies. This research offers much for EM researchers to draw on as they explore the linkages between process and product technology, environmental management and performance. However, much work is required to move theory from firm to sustainability level.

5.5.3 TQEM role towards Sustainability

In the TQEM literature, the argument was advanced and developed that the TQM philosophy and tools can be leveraged for environmental management. Welford (2002), GEMI (1993) and Angell and Klassen (1999) illustrated how several major firms view pollution and inefficiency to be identical problems, combining quality and environmental efforts to obtain a competitive advantage. Hassan (2006) noted that the majority of environmental impacts are relatively small, and therefore are perfect candidates for continual improvement techniques. TQEM literature covers a wide range of topics such as strategic alliances, the deployment of environmental quality and information systems, and performance measurement.

Beside suggesting QA and P-D-C-A for promoting TQM towards sustainability, a research by Hassan (2006) suggested that integrating tools from EM (the LCCA) with another from TQM (the P-D-C-A) could be applied to construction industry for sustainable outcomes. Reed highlighted the LCA role and recommended that EM should be integrated into corporate level of construction management as any capital investment decision in which relatively higher initial costs are traded for reduced future cost obligations (Reed *et al.*, 2000). It is particularly suitable for the evaluation of building design alternatives that satisfy a required level of building performance but may have different initial investment costs, different operating and maintenance and repair costs, and possibly different lives (Green *et al.*, 2007).

LCCA provides a significantly better assessment of the long-term cost-effectiveness of a building project than alternative economic methods that focus only on first costs or on operating-related costs in the short run (Hassan, 2006). Similarly, integrating LCA with the P-D-C-A cycle includes the LCCA as the latter can be considered as a subset of LCA itself. The outcome is integrated with the P-D-C-A cycle. These methodologies could lead to a continuous improvement as the criteria for sustainable buildings (Ofori *et al.*, 2002). For example, the embodied energy in foundations, external walls, slabs, partition wall, floors of a building, require quantified and qualified with respect to the required result, which states that the energy efficiency should be maximized. The embodied energy defined here is the energy that is used during the entire life cycle of the building elements for construction, transporting, and disposing of the building elements.

To conclude, for sustainable construction framework the previous methodologies of LCA, LCCA, P-D-C-A, and QA applications could be required. Those methodologies could be feasible methods to be harnessed towards sustainability of buildings.

5.6 Research Framework

The UK construction industry's contribution to the built environment is a key to climate change adoption, mitigation and long term objective of making the UK a low-carbon society. The demand to resolve its massively-damaging environmental impact cannot be separated from the need to improve the industry overall performance as both have impact on the economy wider performance. The UK construction industry continues to face substantial demands for improvement in terms of productivity, efficiency, quality, cost control, contract disputes, and sustainability. In other words, there is a demand for changing its fire fighting approach into problem solving especially in the new area of interest such as environment and sustainability. The manufacturing industry, stimulated by the advances in technology and changing customer needs, has adopted new management based techniques and working practices, which have brought improvement in productivity, efficiency.

The UK construction industry is complex, operating in ever-changing legislative needs, materials, technology, and constant need for natural and human resources. The spiralling demand for environment and sustainability evolution, in particular increasingly stringent regulation, mirrors the evolution of quality management within construction. The industry underachieving has occupied a place is several government reports and performance initiatives. The level of improvement has still been elusive. Notable amongst the proposed solutions is the concept of considering construction as a manufacturing process through the application of its management-based techniques. The reason for the slow uptake of the manufacturing techniques seems to be the traditional concept of construction uniqueness. Therefore, if the differences between the construction and manufacturing industries are taken into consideration, the benefits of management-based approach can be realised. In fact, some of the construction characteristics may even favour the implementation, i.e. the active participation of the clients in construction process and the current move towards more integrated forms of procurement.

The most obvious problem with altering the new environmental building regulations to bring about significant change is that environment and sustainability principles should be linked to the procurement strategy. It has been argued that D&B is a fundamental approach for better productivity, innovation, and efficiency compared to the traditional procurement strategies. However, these comparisons are often made without reference to design quality and environmental features. Novated D&B attributes depends on whose perspective it is viewed from. Clients regard it as providing value for money. Contractors see it as an opportunity to apply their key strengths in management and coordination of design and construction. Yet, this situation of high adoption and poor quality and environmental performance led this research to develop a management-based performance improvement from novated D&B principal contractors' perspective.

The research problem can be grouped into three main streams: the regulatory, managerial and procurement, and intervention contexts. Firstly, the appeal of the new 2006 performance-based environment building regulations is as much about introducing a management-based approach that overcomes problems of inflexible enforcement as it is about regulating for results. In this case, the solution may be in the development of frameworks for action, identifying sources of knowledge and tools to meet performance based regulations, while considering current availability of materials and labour skill. Secondly, the continuous increase in the use of novated D&B demands a management framework that pictures the interaction between various parties involved in the realization of a project. Thirdly, the problem of intervention is about current D&B practices where construction work starts immediately on site before finalizing the design, based on staged building control approval. A management-based framework is required for careful attention to the output specification to achieve the required quality and environmental outcomes.

To address these problems, TQEM has collectively been defined as an economically-driven, system-wide and integrated approach to the reduction and elimination of all waste systems associated with the design, manufacture, use and/or disposal of products and materials. TQM is a familiar approach for contractors. It enables focus on customer satisfaction, reduction in costs, sustained competitive advantages through systems, people and resources. The construction industry is behind other industry sectors in the adoption of EM concepts. EM is a management process that extends across the construction process through (requirements, responsibilities, and mechanisms). There is no TQEM framework for the UK contractors. The separation of TQM and EM functions could be counterproductive to effective resource allocation. The divide between corporate and project-levels within TQM & EM could make there interaction less effective. Independent EM and TQM in operation may lead to competitive demand for resources or priority attention.

TQEM attributes for principal contractors can be divided into corporate-level and project-level. The corporate level refers to the vertical integration that considers the organisation cultures, stakeholders and systems. The project-level refers to the horizontal integration into a project processes, supply chain, and contractual arrangement. The project-level TQEM in construction projects could include a mix of product and service dimensions. On one hand, the service TQEM dimensions may be easily interpreted as they are directly associated with contracting services. On the other hand, the product TQEM dimensions are associated constructed facility. The interrelationships between the design and the delivery of construction products and services impede defining TQEM dimensions in precise terms.

The decision of a contractor to be TQEM organisation may require many organizational changes on the corporate and project levels. The main drivers could be could be (i) external stakeholder pressures from environmentally aware consumers and public interest groups, (ii) regulatory pressures from environmental agencies and (iii) internal factors which depend on the production related benefits and costs of making such organizational changes and the capabilities of firms to make them. The internal production-related benefits arise because TQEM systems-based approach towards sustainability.

This study investigates novated D&B main contractors' perspectives. The main reason is that the elements of TQEM process of the design and construction systems are not always as visible to the end-users as they are to the contractor. To be able to define these elements in a construction project, contractor's perspectives need to be studied with regard to the corporate-level and project-level. Unlike the traditional methods of procurement, Design-and-Build relies upon a certain amount of concurrency in design and construction. This will benefit TQEM through better coordination between the design and construction teams which will allow TQEM to influence design details, particularly with reference to developing a more sustainable and easily constructed design. Contractors' TQEM performance should be evaluated using the set of TQM and EM factors and indicators. This involves gathering a list of contractors' TQEM drivers, barriers, any benefits that may occur, performance indicators that are derived from various quality-related and environmental-related practices of a contractor at the corporate and project levels.

5.7 Summary

This section attempts to define the role and tasks of integrating TQEM towards building sustainability in the UK construction industry using integrated and holistic concepts. Utilizing a sustainable building design philosophy encourages decisions at each phase of the design process that will reduce negative impacts on the environment and the health of the occupants along with the economical and social gains, without compromising the bottom line.

The discussion advances building sustainability theory by relating TQEM methodologies to building construction. TQEM has the potential of identifying linkages between business decision-making processes and social, environmental, and economic impacts. There are four main drivers for switching to TQEM: (1) Cost savings through energy and other operating efficiencies, particularly during a period of rising fuel, material and labour costs, (2) stakeholder expectations and aspirations (customers, financiers, suppliers etc,) and reputation loss from failure to engage, (3) regulation. The ability to steer a course through and mitigate the widening array of legislation and regulation, and (4) new business ranging from competitive advantage, opportunities changing markets and technologies to capability building, green technology and credit offset strategies.

CHAPTER SIX

RESEARCH METHODOLOGY

CHAPTER SIX: RESEARCH METHODOLOGY

6.1 Introduction

The field of construction management has generated a wealth of research in the last 50 years. The body of knowledge generated as a result has led to considerable improvement in the understanding of the importance of management tool for performance improvement. However many new questions and unresolved problems have emerged since then. Research findings have, in a number of instances, brought the need for developing construction companies' performance, in particular; the demand to address competitiveness, to innovate, to be the first to deliver better quality, environmental and sustainable progress and to create building that fit the purpose were people can live, work and achieve.

Construction management research is at the cross-section of the natural sciences and social sciences (Love *et al.*, 2002). Because of this, there has been a great deal of debate amongst construction management academicians as to which research methodology may be the most appropriate to be used when undertaking construction management research (Rayman and Bell, 2003; Knight and Ruddock, 2008). Nonetheless, this debate has been directed towards the interaction of ontological and epistemological concepts upon construction management research settings.

This chapter presents the research design and methodology adopted to achieve the aim and objectives of this study. This involves some exploration of some of the methodological options available to this study, the methodology adopted and the justification for selecting certain methodology. The sampling criteria and the source of data and analysis are also stated.

6.2 Research Paradigms and Theoretical Assumptions

The research paradigm is defined as a cluster of beliefs and dictates of how research should be done (Love *et al.*, 2002). It is the 'mental window' through which the researcher views the world (Creswell, 1994). According to Creswell, paradigms are used in the social science as a perspective or frame of reference for viewing the social world, consisting of a set of concepts and assumptions. Different research will inevitably result in the generation of different kinds of knowledge and the nature of knowledge produced about built environment, about industries and organisations. Creswell addressed two types of paradigm namely, quantitative and qualitative. Another approach differentiates between two types of paradigms: positivism and interpretivism (Hussy and Hussy, 2006; Knight and Ruddock, 2008). Others, however, classify four paradigms, namely: radical humanist, radical structuralist, interpretive, and functionalist (Burrell and Morgan, 1979). According to Creswell (1994) the two types of paradigm are;

- The quantitative paradigm is termed the traditional, the positivist, the experimental, or the empiricist paradigm. The intent of the quantitative study is to develop generalization that contribute to the theory and that enable one to better predict, explain, and understand some phenomenon.

- The qualitative paradigm is termed the constructivist approach or naturalistic. Qualitative research's categories emerge from informants, rather than are identified a priori by the researcher.

Although these contrasts are heuristic device, seldom do actual studies exemplify all of the ideal characteristics of either paradigm (Creswell, 1994). Hence, TQEM subject matter requires multi-paradigm. This is because TQEM is not only confined to facts (quality and customer satisfaction issues and environmental indicators) but also includes the participants' perceptions (i.e. managers' commitments and companies' culture).

The assumptions of quantitative and qualitative paradigms are based on different ontological and epistemological approaches. This debate has directed limited discussion toward the interaction of ontological (referring to the metaphysical nature of being) and epistemological (referring to the theory of method or grounds of knowledge) concepts. Ontology refers to the conceptions of reality (Bryman and Bell, 2003). Bryman and Bell (2003) divide ontology into two main streams:

- Objectivist Ontology: Sees social phenomena and their meanings as existing independently from the researcher.

- Constructivist Ontology: Infers that social phenomena are produced through social interaction and are therefore in a constant state of revision.

Another ontological type is multiple realities which exist in any given situation (Creswell, 1994). The researcher suggests taking this multiple reality stance as an appropriate approach for extending the scope of TQEM. Since the ontological issue is about what is real, the quantitative researcher sees reality as objective, which can be achieved and measured objectively by using one or more of the available instruments such as, questionnaire, interviews, or case studies. Hence, for TQEM, the participants' thinking (managers' opinions) creates problems that have no counterpart in natural science. In this sense, reality is partly subjective and multiple as seen by participants in study. For example, a fundamental problem concerning EM integration in construction is about predicting human behaviour and approach to environmental value which may be not solely explained scientifically.

Epistemology refers to what should be regarded as acceptable knowledge (Knight and Ruddock, 2008). According to Knight and Ruddock (2008), modern epistemology is divided into:

- Empiricism, where any belief can count as knowledge if, and only if, it is grounded in sets of actual or possible experience.

- Rationalism, in contrast to empirical knowledge, often comes after experience.

As for the epistemological question, the researcher here is independent from what is being researched, and she has to make control for bias, selecting samples, and be objective in assessing a situation. Empiricism epistemology here reflects the relationship of the researcher to what is researched. TQEM framework for D&B

contractors could be developed as a set of beliefs formed around the idea that experience rather than reason is the source of robust knowledge. TQEM requires that the site works undertaken by the principal D&B contractor are managed within an organisation of effective hazard identification, risk assessment, good supervision, and close control. Therefore, supervisors and managers must be cognisant of the dangers inherent to some operations and know fully what actions they need to take to mitigate risks and control the hazards threatened. TQEM throughout a construction project encompasses the consideration of quality and environmental effects at the corporate and project levels.

TQEM subject matter does not exemplify all of the ideal characteristics of either paradigm (quantitative, and qualitative). This is because TQEM is not only confined to facts (quality and customer satisfaction issues and environmental indicators) but also includes the participants' perceptions (i.e. managers' commitments and companies' culture). Therefore researcher suggests taking multiple reality stances as an appropriate ontological approach for extending the scope of TQEM. As for the epistemological approach, the researcher here is independent from what is being researched, and she has to make control for bias, selecting samples, and be objective in assessing a situation.

6.3 Research Hypotheses

The literature findings demonstrate that the bulk of empirical research on environmental management issues has been directed toward quality, strategy, supply chain and process management. The development of TQEM may improve environment, quality, sustainability, client's value for money, and at the same time reduce contractors' risks. Hence, the impact of TQEM on construction management, design, performance, and procurement are not always as visible to the end-users as they are to the contractor.

The literature review, also, reveals that the new construction environmental regulations add significant responsibility on novated D&B main contractors. Motivated by D&B strategy high adoption and poor quality and environmental performance, the research aims to establish the suitability of TQEM for D&B main contractors across the major classification of project types. Based on the literature findings the research hypotheses to investigate are:

- Hypothesis A: There is demand for TQEM in the UK D&B contractors.
- Hypothesis B: TQEM could be implemented in D&B contractors.
- Hypothesis C: TQEM leads to performance improvement towards sustainability for novated D&B contractors.
- Hypothesis D: It is possible to develop TQEM framework for novated D&B contracts.

These hypotheses will be translated into objectives in the following section.

6.4 Research Objectives

To be able to define the previously mentioned hypotheses' key elements, this section highlights these study objectives. To address TQEM suitability for D&B contractors, the research objectives will focus on TQEM key elements. The research objectives should also include investigating TQEM benefits, barriers, key factors, impacts in order to establish TQEM role in D&B contractors' performance improvement. To build up TQEM framework, the research objectives will address D&B contractors' perspectives with regard to the corporate-level TQEM (cultural and business aspects) and project-level TQEM (construction performance and procurement arrangements). The research objectives are:

- To establish the importance of linking TQM and EM into TQEM for improving D&B contractors' performance towards sustainability.
- To find the key factors for integrating TQEM through understanding the benefits and limitations that may occur with regard to the UK D&B contractors.
- To investigate TQEM possible impact on different aspects associated with contractors' performance on the corporate level.
- To understand TQEM possible impact on different aspects associated with D&B main contractors' performance on the project level.

- To develop and validate a framework for TQEM applications for novated D&B main contracts.

To achieve these objectives, the overall approach of the research process will be discussed in the following section.

6.5 Methodological Assumptions and Triangulation

To achieve the previously stated objectives, this section highlights the study methodology. Research methodology is defined as the philosophy of the research process (Knight and Ruddock, 2008). It is the entire process of a study (Creswell, 1994). Hussey and Hussey (2006) argue that methodology refers to the overall approach of the research process. Research methodology includes the assumptions and values that serve as a rationale for research and the standards or criteria the researcher uses for interpreting data and researching conclusions. A researcher's methodology determines such factors as what level of evidence is necessary to take the decision whether or not to reject a hypothesis. Three methodological approaches were discussed by Creswell;

- One approaches a quantitative methodology by using a deductive form of logic where in theories and hypotheses are tested in a cause-and-effect order. Induction always involves some selection of what data to attend, implying 'theory', no matter how implicit.

- Second approaches a qualitative methodology inductive logic prevails. Deductive inference, however, involves some intuitive aspects in that its predictions are tested inductively. Deductive inference is also heavily dependent on the initial step of generating hypotheses (or propositions) from general laws or theories (Love *et al.*, 2002).

- Third methodological triangulation. The use of qualitative methodology inductive logic to corroborate quantitative methodology deductive logic (and vice-versa) (Mingers and Gill, 2007).

The methodological triangulation is seen appropriate for this research. The research departs from a purely deductive approach then will be shifted towards a more inductive approach. The research hypotheses have emerged from the critical literature. To this point the research departs from a purely deductive approach and starts to draw conclusions. This was related back to the literature chapters that stimulated the research in the first place. Going for a survey, for example, may illustrate contractors' demand, barriers and benefits that may occur by implementing TQEM. Although on this point the research is described as deductive, it should be pointed out that classic hypotheses were not easily formulated because the variables and issues identified are mainly contextual and therefore do not translate into simple constructs. Despite the fact that this deductive approach might be vital for investigating TQEM key factors, the inductive approach might be useful for capturing the intangible barriers associated such as the manager's opinion and the company culture. After starting as deductive, this research will be shifted towards a more inductive approach in the later stage with case studies. This is to explore the primary TQEM framework validity and to consider managers opinions, so that the framework could capture the relationship between the parties involved in a project.

Many important developments in construction management research owe their existence to the development of methodological triangulation techniques. According to Teddlie (2007) triangulation is a means of representation based on the logic that a truer picture can be obtained by taking multiple measurements, using multiple methods, or at multiple levels of analysis. Denzin (1978) provided four types of triangulation:

- Data triangulation: in this context data is collected at different times from different sources.

- Investigator triangulation: the data is collected by different researchers studying the same phenomena independently and comparing the results.

- Methodological triangulation: this method represents using both quantitative and qualitative data.

- Triangulation of theories: take theories from one discipline to be used for explaining phenomenon in another discipline.

The vast majority of empirical research in construction management is highly dependent on qualitative and quantitative methods in developing strategies, frameworks or code of practises (Rayman and Bell, 2003). A factor such as triangulation in research methods contributes significantly to the extensive use of empirical and constructive studies (Love *et al.*, 2002). Researchers are concern of testing the validity of their theories, explaining the functioning, and performance of construction companies (Teddlie *et al.*, 2007). For this research, through methodological triangulation, the researcher elucidates the process of TQEM meaning and clarify what and how meanings are embodied in the concepts (merging the two concepts of TQM and EM), actions (TQEM practices, barriers and benefits) and social actors' opinions (managers commitments and organisation culture).

This research starts as deductive then it will be shifted towards a more inductive approach in the later stage with case studies. Despite the fact that this deductive approach might be vital for investigating TQEM key factors, the inductive approach might be useful for capturing the intangible barriers associated such as the manager's opinion and the construction industry culture. The use of methodological triangulation (quantitative and qualitative data collection methods) will enable having variables at the subject level and the level of observation, developing a primary TQEM framework, then exploring its validity and capturing the relationship between the parties involved in a project.

6.6 The Combination of Methods and Designs

At this stage, it is useful to consider the method for data collection and analysis to be associated with the multi-paradigm. This section highlights the combination of methods used within the quantitative and qualitative paradigms.

- Quantitative paradigm methods: This approach seeks the factors of social phenomena with little consideration of the individual subjective state. Thus, positivism enhances objective logical reasons in investigating the research problem. According to Hussey and Hussey (2006), the positivistic extreme is associated with four main types of study: Cross-sectional studies, experimental studies, longitudinal studies, and surveys. Creswell (1994) considered quantitative methods as consisting of two types:

- Experiments include true experiments with the random assignment of subject to treatment conditions and quasi experiments that use nonrandomized designs. Included within quasi experiments are single-subject designs.

- Surveys include cross-sectional and longitudinal studies using questionnaires or structured interviews for data collection with the intent of generalizing from a sample to a population.

* Qualitative paradigm methods: The phenomenological approach is associated with the seven following type of study: action research, case studies, ethnography, hermeneutics, and participative enquiry (Hussey and Hussey, 2006). Creswell (1994) considered qualitative methods as consisting of two types:

    - Ethnographies: in which the researcher studies an intact cultural group in a natural setting during a periods of time by collecting observational data.

    - Grounded theory: in which the researcher attempts to derive a theory by using multiple stages of data collection and the refinement and interrelationship of categories of information.

    - Case studies: in which the researcher explores a single entity or phenomenon "the case" bounded by time and activity and collects detailed information by using a variety of data collection procedures during a sustained period of time.

    - Phenomenological studies: in which human experiences are examined through the detailed descriptions of the people being studied.

Many important developments in construction management owe their existence to the development of management tools and techniques. Modern performance initiatives are highly dependent on management tools, techniques, and standards. The vast majority of empirical research in construction management is highly dependent on either qualitative or quantitative methods in developing strategies, frameworks or code of practises (Rayman and Bell, 2003). The previous researches on TQM and EM appear to follow either using survey (Arditi *et al.*, 2002; Ofori, 2006, Ng *et al.*, 2006;

Harrrington *et al.*, 2008; Curkuvic and Srouf, 2007) or case study (Welford, 2000; Yousof, 2001, Greenwood and Hamza, 2009, Hassan, 2006) for data collection. For the case study based researches, the benefits were capturing the decision makers' opinion on 'how' TQM can be integrated in construction companies. In comparison, the survey-based studies have the advantages of answering the 'what' question with its ability to cover a wide number of companies. Therefore, this study will use multiple methods of data collection and analysis (survey and case studies). Hence, the use of both quantitative and qualitative data collection methods will enable having variables at: a) the subject level (corporate-level TQEM using a survey), and b) the level of observation (project-level TQEM using case studies).

Given this multiple methods, there are three models for combined designs, according to Creswell (1994);

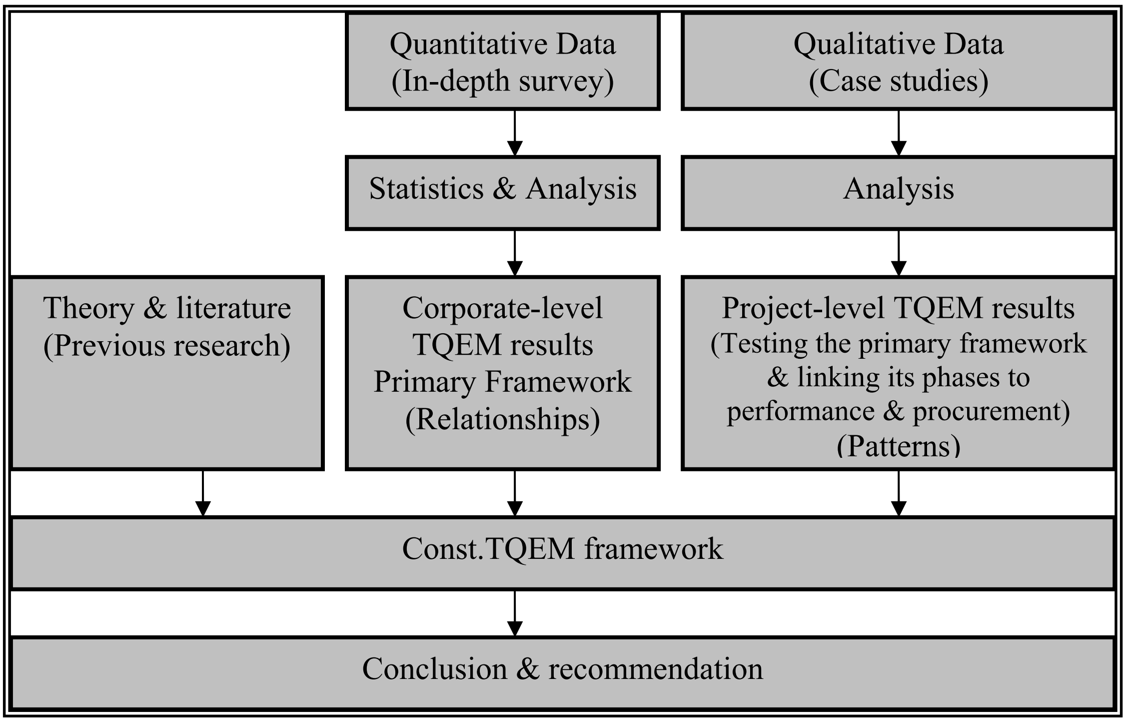
- The Two-phase design approach in which the researcher proposes to conduct a qualitative phase of the study and a separate quantitative phase of the study. The main advantage of this approach is that the two paradigms are clearly separate.

- Dominant-less dominant design. In this design the researcher presents the study within a single dominant paradigm with one small component of the study drawn from the alternative paradigm.

- The mixed-methodology design. This design represents the highest degree of mixing paradigms. The researcher would mix aspects of the qualitative and quantitative paradigm at all or many methodological steps in the design.

Research design is the process of situating the researcher in the empirical world and connecting research questions to data (Denzin and Lincoln, 2000). Making decisions about research design is fundamental to both the philosophy underpinning research and the contributions that the research can make (Love *et al.*, 2002). This research adapts two-phase design approach. The main advantage of this approach is that the two paradigms are clearly separate, as can be seen in figure 6-1. Whereas quantitative phase places emphasis on facts and connections for developing corporate-level TQEM primary framework, with qualitative phase the project-level TQEM entails a process for testing the primary framework and placing emphasis on managers' opinion. This approach contributes significantly to the extensive use of empirical constructive studies (Teddlie *et al.*, 2007). The researcher here is concern of testing the validity of TQEM theory, explaining the functioning, and performance of construction companies.

Figure 6-1: The research design



The central premise of this research is to study the suitability of TQEM for improving novated D&B contractors' performance, an idea that has a little support in the literature which has investigated TQM and EM integration in the construction sector but require further validation. For that the research adapts two-phase design approach. Phase one is a quantitative study that will look at statistical relationships between integrating TQM and EM and the barriers and benefits that may occur in D&B contractors. Following this macro level analysis, phase two within specific D&B contractors, using qualitative/case study method to better understand the dynamics of the project-level (managers' commitments and the relationship between the parties involved in the project realization). An extensive literature is used to document the concepts of (procurement, performance improvement, TQM, EM, sustainability). A conceptual framework will follow (complete with a visual model). The research questions are posed to explore the relationships. The results also will be presented in terms of phases. The quantitative results will present correlations and regression on the corporate-level. Then the case study results will be presented in terms of themes supported by quotes for testing the primary TQEM and pointing out project-level TQEM component.

6.7 Component of the Survey Method Plan

This section advances the essential steps in this research survey. It presents the survey design, questionnaire design, variables in the study, and data analysis.

A survey is normally a positivistic methodology whereby a sample of subjects is drawn from a population and studied to make inference about the population (Hussey and Hussy, 2006). The authors discussed two main types of surveys:

(1) Descriptive surveys, which are concerned with identifying and counting the frequency of a specific population, either at one point or various times for comparison, and

(2) Analytical surveys, where the intention is to determine whether there is any relationship or 'association' between different variables.

According to this classification, this study's survey is analytical, as it aims to investigate whether there is a demand for TQEM, an awareness of TQEM, performance improvement towards sustainability and key factors and their relationships for developing TQEM framework for UK main contractors.

The site of this study is novated D&B contractors who are mostly affected by the new environmental legislation. Hence, there are two broad sampling methods categories:

(1) A probability sampling scheme is one in which every unit in the population has a chance of being selected in the sample, and this probability can be accurately determined (Teddlie *et al.*, 2007). Probability sampling includes: Simple Random Sampling, Systematic Sampling, Stratified Sampling, Probability Proportional to Size Sampling, and Cluster or Multistage Sampling.

(2) Nonprobability sampling is any sampling method where some elements of the population have no chance of selection, or where the probability of selection cannot be accurately determined. It involves the selection of elements based on assumptions regarding the population of interest, which forms the criteria for selection (Teddlie *et*

al., 2007). Hence, because the selection of elements is nonrandom, nonprobability sampling does not allow the estimation of sampling errors. These conditions place limits on how much information a sample can provide about the population. Nonprobability Sampling includes: Accidental Sampling, Quota Sampling and Purposive Sampling. In addition, nonresponse effects may turn any probability design into a nonprobability design if the characteristics of nonresponse are not well understood, since nonresponse effectively modifies each element's probability of being sampled.

To provide a sample that will answer the research questions under investigation, the survey phase entails the identification of a nonprobability quota sampling frame of those D&B contractors likely to be most affected by the new environmental regulations. To establish TQEM suitability across the major sectors of main D&B contractors, quota sampling means that the population is first segmented into mutually exclusive sub-groups for proportional representation of the five primary categories (housing, non-housing, infrastructure, repair and maintenance, and different market segments) with inclusion being based upon the following criteria:

- That each had operations on a national scale.
- That they have experienced working as a principal contractor within D&B contracts.
- That they had required environmental strategies to meet or exceed the new environmental regulations and initiatives' requirements.

The survey was conducted in 2006-2007. Since non-probability quota sampling is not based on probability principles, there is little guidance available as to how large samples ought to be and no way of estimating confidence intervals for them (Gomm, 2008: 151). Inspired by the lists of the 150 top contractors issued yearly by the Royal Institution of Charted Surveyors (RICS), this study selects 150 reputable D&B main contractors. This sample frame was initially informed by background literature, the supervisors' guidance, the experience of the researcher. Based on the assumption of D&B procurement method, the researcher identified a group likely to be most affected by the environmental drivers and have a decision-making capacity. These criteria could contribute to establishing the key factors of corporate-level TQEM. Further information about the selected contractors was collected from the Kompass data base, Keynotes reports, the Callcutt review, and contractors' websites. The primary sample frame can be divided into two broad types:

1) General construction companies (25) such as AMEC, Costain, and Balfour Beatty with interests in several sectors (for example, infrastructure, housing, commercial, and support services), and

2) Specialist companies, such as Barratt and Bellway in the house building segment and other companies specialised in only one segment (20 non-housing, 20 housing, 35 infrastructure, 50 repair and maintenance).

The survey data are collected by means of questionnaires. A questionnaire is a pre-formulated written set of questions to which a respondent records their answers, usually within rather closely defined alternatives (Bryman, 2003). Questionnaires can be administrated personally, mailed to the respondents, or electronically distributed (Hussy and Hussey, 2006). A questionnaire by email has certain advantages that make it attractive and a good choice for this study. Questionnaires by email can cover a large number of people and a wide-spread geographical area within a short period of time (Hussey and Hussey, 2006). These advantages are seen as relevant to the nature and circumstances of the investigation as the emailed questionnaires are emailed to the quality or environmental managers and monitored by phone calls in many cases to get a statistically representative sample. This questionnaire is developed and tested on three companies before its distribution on the sample.

The questionnaire is designed to test the hypotheses and establish a foundation for the framework in the light of the research objectives. In designing the questionnaire, attention was paid to the types, format, sequence, and clarity of the questions. Different question types (open, closed, and questions of facts or opinion) were used in the questionnaire. Initially, it consisted of three parts:

(a) Company background, including the annual turnover, number of employees and the respondent's job title.

(b) The demand side, including the management approaches implemented the benefits, the barriers, and the level of implementing TQEM towards sustainability.

(c) The key factors for integrating TQEM in construction companies. This includes the systems being used, linkage to adding value to constriction stages, and the key performance indicators.

This paragraph outlines the steps to be taken in administrating and following up the survey to obtain a high response rate. The administration period covers 8 weeks. The emailed questionnaire is designed, tested then modified as the scope of the questionnaire appears to be wide, rather long, and a few questions appeared to be ambiguous, and stating the company name appeared as a major drive for bias. To overcome this, simple definitions were provided for the terms used. For example, using the five levels of strategic TQEM and indicating their definitions, questioning the company TQEM attitude, systems, drivers, and awareness of TQEM. Another example is, when questioning contractors' awareness of TQEM, the questionnaire differentiates between TQM, EM and defines TQEM as integrating TQM and EM. This is mainly because, based on TQEM definition and systems discussed in Chapter Four, the awareness of any quality or environmental initiatives and systems should be counted when deciding on TQEM attributes for contractors. Further, some open questions are used to leave some space for respondent's opinion.

The questionnaire can be seen in Appendix A. It aims to investigate the hypotheses that there are: a demand for TQEM, an awareness of TQEM, performance improvement towards sustainability and key factors for developing TQEM framework for UK main contractors. To achieve this, the survey questions should include the variables of contractors' TQEM awareness, barriers, KPI, levels of progress towards sustainability, integration across construction stages and benefits that may occur from integrating TQEM. Items 6, 8, 10, and 11 in the questionnaire address the research Q1: Is there a demand for TQEM towards sustainability for the UK novated D&B principal contractors? Items 7, 8, and 9 in the questionnaire address Q2: What are the key factors for integrating TQEM for novated D&B principal contractors? Q3: What impacts could TQEM have on contractors' corporate level? and Q4: Is it possible to develop primary corporate-level TQEM framework? are addressed through out the questionnaire's items.

The Personal Computer version of the Statistical Package for Social Scientist (SPSS) and Microsoft Excel are used to analyse the responses received. Collecting primary data through descriptive analysis using Microsoft Excel assists the enhancement of SPSS package effectively, as the data type held by each question must be determined first. Since the sample is purposive no parametric tests is required as the validity and normality test are designed for a normal probability sample only (Saunders *et al.*, 2003). However, surveys using quota sampling by the top companies have been almost as accurate at predicting election results as surveys based on probability samples for addressing the research objectives (Charmers, 2006: 100).

The purpose of this survey is to examine the importance of linking TQM and EM (the independent variables) into TQEM (the dependent variable). Contractors' key performance indicators towards sustainability will be questioned. To find the key factors for integrating TQEM, the benefits and limitations that may occur from integrating TQEM will be examined. The purpose of the selected sample frame is to generate representation and to address the research questions. Thus, this study's particular setting of principal D&B contractors suggests a non-probability sampling deliberately selected for the important information they can provide on TQEM key factors on the corporate-level. To link these corporate-level factors with the contractors' procurement and construction cycle, the following case studies procedure is adapted.

6.8 The Case Studies Procedure

This section presents the research case studies procedures. It advances the data collection procedures, data recording procedures, data analysis procedures within the study narrative. A case study is a research strategy used when attempting to understand complex organisation problems; in essence allowing one to focus on something which is sufficiently manageable and can be understood in all its complexity (Yin, 1994). Many examples exist which have employed this method for testing research validity in implementing TQM or EM research, for example Yosuf (2001), Wiley and Fellows (2008) and Naoum (2006). Yin (1994) suggests that the case study method is especially appropriate when trying to answer 'how' and 'why' questions of research.

As this research aims to answer some of the 'how' questions in TQEM implementation, the case study is believed to be a suitable method. While the survey data feeds into the corporate-level TQEM, the case studies involve more detailed investigation on the project-level TQEM in terms of construction performance and procurement.

Yin (1994) described two basic types of case study design – single-case and multiple-cases. The choice between single-case and multiple-case design depends on the nature of the research questions and objectives, and on the amount of resources available. Evidence from multiple cases is often more compelling, and the overall study can therefore be regarded as being more robust (Wiley and Fellows, 2008). Conducting multiple case studies is described as being similar to replication or executing multiple experiments. The holistic approach (single unit of analysis) is more suitable in examining the global nature of a problem, programme, or an organisation. In the case of this research, the design employed is a holistic multiple-case one which involves examining a particular companies' approach towards TQEM implementation. Since the focus is main D&B contractor as a whole, replicating the case study meant that the management context, strategies, plans, approaches could be scrutinised, analyzed, and developed into a TQEM management-based approach which would hopefully be sufficiently general for implementation purposes. This approach then will be linked with the construction procurement, Design-and-Build, through the use of the case studies that aim to answer the question, *how can the framework management phases be linked to construction procurement?*

Using the case study method is beneficial in this study. It has a key role in addressing and uncovering the main issues which are crucial to this study:

- How has the company approached TQEM?
- Why has the company chosen the particular approach?
- How can the framework management phases be linked to construction cycle and procurement system?

In addition to these questions, the case study also investigates the hypothesis validity and the feasibility of the primary TQEM framework in terms of its strengths, weaknesses, simplicity, practicality. The question is: Can the proposed framework be used as a planning tool, or a guide for TQEM implementation?

The selected case studies should have operations on a national scale, had quality and environmental management strategies, and had experienced working as principal D&B contractors. The case studies test the primary framework developed following from the survey. This framework corporate-level will then be linked to project-level TQEM throughout the construction cycle. A deeper investigation is required for project-level TQEM through case studies. The three case studies are selected based on local accessibility and readiness to participate in the research beside the previous polite point criteria. In each case study the interviewees' organisational levels were coded as shown in Table 9-1. The comments included in the case study results and cross-case examination chapters are referenced accordingly.

Each of the companies is treated as one unit of analysis and it is hoped that through this approach the final framework developed would be generic, rather than one limited to a single specific construction activity. The case companies need to be with different construction activities or processes being employed. Following the analysis, the companies are categorised on their strategic levels of TQEM.

With regard to the interviews conducted within the case studies, Bryman (2003) opines three types of interviews: (a) In the qualitative approach the researcher is primarily interested in the interviewee's subjective view in following the qualitative paradigm. The same person can be interviewed more than one time and the researcher seeks to get detailed answers. (b) In the quantitative approach one person will be interviewed one time on one occasion and the interview is supposed to generate answers which can be coded and processed quickly. (c) Semi-structured interviews, where the research should have a question list or certain specific points to be covered through the interview. Semi-structured interviews are appropriate for this study where the interview guide does not strictly follow a schedule, but similar wording should be used from one interview to another.

The semi-structured interview is seen as applicable for this study as it tends to be more flexible. The areas for exploration with respondents are (as discussed in Chapter Ten):

1. The measures and results gained, together with the range of TQEM improvement initiatives embarked upon by the company, provided a good indicator of 'how

TQEM' the company is. The analysis is primarily conducted through cross-case examination between the companies to look for differences and similarities, thus ensuring that important lessons are learned.

2. TQEM impact on design and decision making in D&B projects.

3. The impact of TQEM on bidding documents in D&B projects.

4. Whether compliance with building environment regulations had led to an increase in the factoring-in of risk margins anywhere in the design and construction process.

5. Control measures to reduce risk of non-compliance with the new performance-based environmental regulations.

The basis on which contractors' performance towards TQEM is judged are the managers' opinions, document analysis, observations at the company premises and project sites, and their actual progress after implementing related TQEM systems and initiatives. It will not be considered when classifying the companies since this will require them to disclose confidential information, which some may not be willing to do.

The Case Study Protocol facilitates data collection. A compensation of data collection approaches is used (interviews, observations, documents). Beyond these approaches, the researcher considers four parameters: (a) the settings (the research will take place at the company premises and project sites); (b) the actors (three selected case studies of D&B main contractors, interviewees are grouped into top, middle and project level management, are coded (i.e. Chief Exhibitive, Quality Managers, Environmental Managers, Sustainability Champions and project managers), (c) the events (those actors will be observed and interviewed about D&B projects), and (d) the process involving nature of project performance and procurement and the relationship between the different parties involved in project realization).

The case study protocol is developed for an appropriate data recording procedures. The observational protocol includes information about the time, performance, and place where the observation takes place. A protocol also is also useful in conducting interviews including (instructions to the interviewee), the key research questions to be asked, probes to follow the research questions, space for recording the interviewee's comments on the primary TQEM framework and on linking its phases with project-level TQEM. The researcher record information from interviews by using note taking and audiotapes in some cases and then transcribes the interviews later. The protocol for the recording information is established to investigate the company quality and environmental standards. The case study protocol includes some general information about the company, such as the types of building activity, the year in which the first quality or environment initiative was started, etc. Chapter Nine deals with the following implementation issues:

1. To encompass four major TQEM implementation key factors; a) management/leadership, b) continuous improvement, c) systems and businesses, and d) actual implementation.

2. To determine the type of implementation framework used by the company.

3. To investigate which of the various TQEM initiatives have been implemented, including both technical and soft/motivational aspects. TQEM improvements are not only concerned with hardware but they also include the soft human aspects such as better communication links, employee's recognition scheme, etc.

4. To ascertain how well the company had progressed towards TQEM, through the measures developed for TQEM performance.

5. To evaluate the primary TQEM framework that will be developed following from the survey findings.

The data analysis procedures include coding the interviewees. Coding means; categorizing segments of data with a short name that summarizes and accounts for each piece of data (Charmaz, 2006: 43). Coding provides the pivotal link between collecting data and developing an emergent theory to explain these data (Gomm, 2008: 301). The case studies' interviewees are coded, as can be seen in Table 9-1, to keep it anonymous.

The purpose of the case studies will be to understand TQEM possible impact on different aspects associated with contractors' performance and procurement. At this stage in the research Const.TQEM (the central concept being studied) will be defined. Understanding the case studies' informants' professional standing and the significance of their comments are enhanced to ensure the primary TQEM framework external validity. The framework is developed further through the provision of rich, thick detailed description out of the case studies which allow any other D&B contractor interested in transferability to have a solid framework for comparison. The intention is to validate the concepts presented in the primary framework through open-ended. The managers will be asked to give their comments on the framework; feasibility, ease of implementation, and overall structure..

6.9 Limitations

The researcher is aware of several issues that may affect the quality of the research data gathered through the survey and case studies. Some of these issues are inherent in the e-mailed questionnaire technique which may affect the response rate, the reliability, and validity of the data collected. The response rates, validity and reliability can be maximized, according to Saunders *et al.* (2006), by: careful design of individual questions, clear layout of the questionnaire form, explanation of the purpose of the questionnaire, pilot testing, carefully-planned sample frame and executed administration.

The emailed questionnaire is easy to complete, interesting and less time-consuming. The questionnaires are attached to cover letters that elaborate the research aims (Appendix 2) and are emailed to the companies' quality or environmental managers where possible. The questionnaires are tested and distributed, leaving two months for correspondents' responses, and are monitored by phone calls for reminding.

Although the selected non-probability sample is not being considered as statistically representative of the construction companies' total population, it provides a judgemental approach to select cases that will best enable answering the research questions (Saunders *et al.*, 2006). A variation quota sampling within a relatively small sample (compared to the number of the registered UK contractors), may contain cases that are different. Naoum (2006) argues that this is in fact a strength. Any patterns that do emerge are likely to be of particular interest and value and represent the key themes (Bryman, 2003). The data collected in this approach enable the researcher to document uniqueness (Saunders *et al.*, 2006).

In the case studies, the findings could be subject to other interpretations due to interviews' bias or confidential information unavailable for the researcher site observation or document analysis. Hence, interviews are useful when information can not be directly observed while the research should always control over the line of questioning (Saunders *et al.*, 2006).

In addition, the triangulation approach serves to ensure that the data is reliable, and it may resolve the classic methodological trade-off involved in the choice of sample size. The case studies go behind the survey responses to question the impact of TQEM on the contractors' management, performance, and procurement. Purposive sampling leads to greater depth of information from a smaller number of carefully selected to be representative of the population. The second phase of the investigation is explained in the following chapter.

6.10 Issues of Validity and Reliability

Validity and reliability are important criteria in establishing and assisting the quality of the research hypothesis. According to Hussey and Hussey (2006), reliability is concerned with the findings of the research and is one aspect of the credibility of the findings. In other words, if the researcher repeats the research under similar conditions of the original research, and the same results were achieved, then it can be said that reliability is available (Hussey and Hussey, 2006). The authors state that validity is the extent to which the researcher's findings accurately represent what is really happening in the situation. In this context, Rayman and Bell (2003) stated the following categories:

- External reliability for a study to be replicated.
- Internal reliability for inter-observer consistency.
- Internal validity for a high level of congruence between concepts and observations.
- External validity for the degree to which findings can be generalized.

It is suggested that qualitative and quantitative research should be evaluated according to different criteria (Lincolin, 1994; Rayman and Bell, 2003). In this research the quantitative method (the survey) is used to develop a primary TQEM corporate-level framework. Validity is a critical issue in the qualitative research because of the tendency to employ approachable case studies. Understanding the case studies' informants' professional standing and the significance of their comments, in semi structured interviews, is enhanced to ensure the primary TQEM framework external validity. The framework is developed further through the provision of rich, thick detailed description out of the case studies which allow any other D&B contractor interested in transferability to have a solid framework for comparison. The triangulation is vital for judging credibility (Gomm, 2008: 242).

Many tests are conducted for the purpose of testing theories. Researchers are concerned with testing the validity of their theories, explaining the functioning, and performance of construction companies. This research undertakes an analytical survey of the literature review findings. The discussion of the survey results forms the foundation for developing a primary TQEM framework. The framework is then tested on three case studies to link its corporate-level TQEM with the project-level TQEM and with construction stages and procurement. The case studies examine the hypothesis validity, therefore the study benefits from triangulation in ensuring the data validity.

6.11 Summary

This chapter highlights this research objectives, hypotheses, paradigms, methodologies, and methods, and the research design. A triangulation approach is suggested for better insight on D&B principal contractors' quality and environmental performance. A combination of survey and case studies is selected due to two main reasons. 1) The two different methods are used for different purposes as the survey focuses on corporate-level TQEM while the case studies concern with the project-level TQEM. 2) This use of multi-methods enables triangulation to take place in order to ensure that the data is reliable.

The chapter suggests taking multiple reality stances as an appropriate ontological approach for extending the scope of TQEM. The reason is that TQEM subject matter does not exemplify all of the ideal characteristics of either paradigm (quantitative, and qualitative). This is because TQEM is not only confined to facts (quality and customer satisfaction issues and environmental indicators) but also includes the participants' perceptions (i.e. managers' commitments and companies' culture).

The design and administration of the questionnaire and the case studies protocol are designed to cover TQEM attributes. The attributes of TQEM systems is divided into corporate-level and project-level. This is mainly because the concept of TQEM requires organisations to establish a well-structured and explicit system that identifies, documents, co-ordinates and maintains all the key quality and environmental-related activities throughout all relevant contractor's company and site operations. The result of first phase of investigation, the survey, is presented in the following chapter.

CHAPTER SEVEN

THE SURVEY RESULTS

CHAPTER SEVEN: THE SURVEY RESULTS

7.1 Introduction

An effective TQEM framework for construction performance improvement must be firmly located in present reality of the industry. With regard to the research Hypotheses A and B, the demand and the main key factors that could affect TQEM implementation will be investigated by the survey results and analysis. The survey sampling, questionnaire design, and limitations were discussed in Chapter Six.

The purpose of this survey is to examine the importance of linking TQM and EM (the dependent variables) into TQEM (the dependent variable). Contractors' key performance indicators towards sustainability will be questioned. For finding the key factors for integrating TQEM, the benefits and limitations that may occur from integrating TQEM will be examined.

The survey was conducted in 2006 to uncover the key factors of integrating TQEM on the corporate-level, to explore the set of core values that TQEM could add to contractors' performance, and to develop a primary TQEM framework. This framework could promote delivering increased value to clients and improvement of overall contractors' performance and capabilities on the corporate-level. The results shown in this chapter refer to the TQEM vertical integration for contractors in terms of business and attitude or culture. The barriers, benefits that may result form implementing TQEM for contractors are presented in this chapter.

7.2 Response rate

57 respondents returned data by the specified deadline. However, 50 questionnaires only are considered for the following reasons: one was empty and six were not fully completed.

Since it is not probability sample, no parametric tests are required as the validity and normality tests are designed for a normal probability sample only (Saunders *et al.*, 2003). Since quota sampling is not based on probability principles, there is little guidance available as to how large samples ought to be and no way of estimating confidence intervals for them (Gomm, 2008: 151). However, surveys using quota sampling by the top companies have been almost as accurate at predicting election results as surveys based on probability samples for addressing the research objectives (Charmers, 2006: 100).

The construction sector is dominated by 23 major contractors which contribute to 70% to the market value (according to the Keynote discussed in Chapter Two). Therefore, 12 respondents, out of those 23 major contractors, represent 40% of the market value. 50 responses means 33% response rate. Although 50 represents is a small portion of the building contractors, the results are weighted. 33% response may reflect contractors' demand for a solution to the challenging new environmental legislation (discussed in Chapter Two). Hence, the triangulation approach implemented in this study aims to insure the data reliability as the case studies will go behind the survey answers.

7.3 Respondents' characteristics

Generally the survey respondents can be divided into two broad types:

1) General construction companies such as AMEC, Costain, and Balfour Beatty with interests in several sectors (for example, infrastructure, housing, commercial, and support services), and

2) Specialist companies, such as Barratt and Bellway in the house building segment and other companies specialised in only one segment (for example, infrastructure, housing, non housing (i.e. commercial, industrial), and repair and maintenance support services).

Hence, all the survey companies share extensive experience in working as main D&B contractors. In other words, all the respondents are organisations which are contracted by clients to manage the design and construction processes. Table 7-1 shows a summary of the responses from 50 contractors. It shows the number of companies in different market segments and the number of those companies grouped by amount of annual turnover.

Table 7-1: Company characteristics

Respondents' Market Segments				
Housing	**Non-housing**	**Infrastructure**	**Repair & Maintenance**	**General Construction**
12	5	7	9	15
Annual Turn Over				
< £5m	£5m-< £10m	£11m-£50m	£51m-£100m	>£100m
22	11	9	5	3

Contractors' output in new housing increased by 38% (8.4% per annum) over the 5 year period to 2005 (Callcutt review, 2007). This may be the reason for the high percentage of housing contractors among respondents. Another reason may be that the housing industry was found to be more standardized than the other construction sectors (Egan, 1998) which suggests more applicability for implementing manufacturing management-based techniques. The growth in this sector and the possibility of standardizing its processes may motivate housing contractors to implement TQEM.

The respondents' characteristics are presented in table 7-2. Despite the fact that the questionnaires were emailed to managers who deal with quality and environmental issues, with 70% of the respondents indicated that they are not quality or environmental managers. The questionnaires may have been forwarded to project managers or supervisors to respond to. This reflects that quality and environment-related decision-making criteria may lie in the hands of lower-level management on site rather than starting from the strategic planning and design stage.

Table 7-2: Respondents' characteristics

MD	**Director**	**Quality/Environmental Manager**	**Others**
10%	8%	12%	70%

7.4 Awareness of TQEM

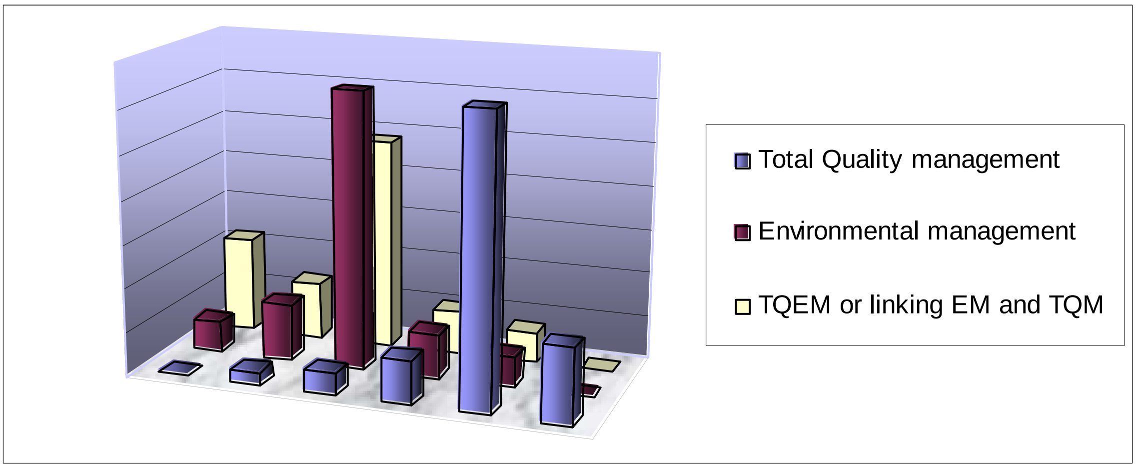
It was hypothesized that construction companies are not aware of TQEM, which is the reason why the survey questioned the awareness of TQM and EM separately and provided a simple introduction to TQEM in terms of linking TQM with EM. As can be seen in Table 7-3 and Figure 7-1, the majority of the responding firms (65%)

indicated that they have experienced quality management for 5–10 years. The majority of the responding contractors (63%) have been involved with environmental management for 1–3 years. 48% indicated linking TQEM and EM. These figures reflect the literature findings that the employment of EM in the construction sector mirrors the TQM implementation ten years ago driven mainly by the new environmental regulations and customer satisfaction.

Table 7-3: Awareness of TQEM

Awareness	Not yet	< 1	1 - 3	4 - 6	7 - 10	>10
TQM	0%	3%	5%	10%	65%	17%
EM	7%	13%	63%	10%	7%	0%
TQEM	22%	13%	48%	10%	7%	0%

Figure 7-1: Awareness of TQEM



The relationship among TQEM, TQM and EM awareness depends on the shared principles between TQM and EM, i.e. waste minimisation and energy efficiency (explained in Chapter Four). The more the respondents are aware of TQM and EM the more they clam awareness of TQEM (Table 7-3). The 14 respondents who indicated linking TQM and EM for 1-3 years have experienced TQM for 7–10 years and have implemented EM for 1–3 years. This suggests that the link between TQM and EM has emerged roughly the same time as EM, following from longer experience with TQM.

Table 7-4 shows the relationship between TQEM awareness and the respondents' sectors. Out of the respondents' 12 housing contractors, 10 contractors indicated 1–3 years awareness with TQEM. Out of the 5 non-housing contractors, 2 claim linking

TQM and EM for 4–6 years. The majority of the infrastructure contractors who responded to the survey indicated 1–3 years' experience with TQEM. On one hand, the majority of the repair and maintenance responded contractors appear to be not aware of TQEM. On the other hand, 5 of the 15 contractors with different market sectors who responded to the survey indicated 7–10 years' experience with TQEM. The awareness of TQEM varies across the construction sectors, yet the majority of the responses 50% indicated 1–3 years awareness of TQEM. This is probably due to the recent introduction of environmental regulations (i.e. Part L, 2006).

Table 7-4: Awareness of TQEM across construction sectors

			type						Total
			Housing	Infrastructure	Other	Non-housing	Repair and Maintenance	Different market segments	
TQEM	<1	Count	0	2	1	1	2	0	6
		% within type	.0%	28.7%	20.0%	20.0%	28.6%	.0%	12.0%
	No	Count	0	0	1	0	5	0	6
		% within type	.0%	.0%	20.0%	.0%	71.4%	.0%	12.0%
	1-3	Count	10	5	0	2	2	6	25
		% within type	83.3%	71.1%	.0%	28.6%	28.6%	46.2%	50.0%
	4-6	Count	1	0	0	2	0	4	7
		% within type	8.3%	.0%	.0%	28.6%	.0%	30.8%	14.0%
	7-10	Count	1	0	0	0	0	5	6
		% within type	8.3%	.0%	.0%	.0%	.0%	71.1%	12.0%
Total		Count	12	7	2	5	9	15	50
		% within type	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Table 7-5 shows the relationship between TQEM awareness and the respondents' turnover. Within these respondents, it appears that the higher the company turnover the more the company is aware of TQEM. While the majority of the respondents' turnover is with less than £5 million yet the majority of those are have no TQEM awareness. The majority of the high turnover respondents have 6–4 years' TQEM awareness.

Table 7-5: Awareness of TQEM and contractors' turn over

			turnover			Total
			< 5m	5-10 m	11m+	
TQEM	<1	Count	7	2	0	9
		% within turnover	28.0%	33.0%	.0%	18.0%
	No	Count	8	1	0	9
		% within turnover	32.0%	16.0%	.0%	18.0%
	1-3	Count	5	2	5	12
		% within turnover	28.0%	33.0%	20.8%	24.0%
	4-6	Count	0	1	5	6
		% within turnover	.0%	16.0%	20.8%	12.0%
	7-10	Count	0	0	4	4
		% within turnover	.0%	.0%	16.7%	8.0%
Total		Count	22	6	17	50
		% within turnover	100.0%	100.0%	100.0%	100.0%

7.5 Strategic levels of integrating TQEM

The results revealed in the previous section illustrate some awareness to TQEM. Yet to investigate the level of TQEM awareness towards sustainability, the questionnaire investigated the following criteria that address the needs and the environmental and quality practices associated with each following levels:

- Compliant: which is the minimum level an organisation can adopt for being in compliance with separate quality, environmental, health and safety regulations.

- Informed: spending time and resources collecting information on the link between quality and environmental and sustainability programmes, as key activities to go beyond compliance and participate in external activities as a trade association.

- Market-Driven: in this sense, the response is not only to regulatory requirements, but also is 'reactive' to clients' quality/environmental expectations in terms of providing leading product/services and operational performance.

- Competitive Advantages: within this level, an organisation understands its quality/environmental market opportunities and navigates to leadership market position by proactively using knowledge.

- Sustainable: the highest level when an organisation proactively integrates economic growth; quality, environmental, health and safety and social well-being into its operations for competitive advantage and long term viability.

When asked to position their organisations with regards to these levels, 63.1% of the respondents evaluate their TQEM performance in the compliance level. 6.6% of responses indicated reaching a competitive level through their quality and environmental practices.

Table 7-6: Strategic levels of integrating TQEM

Compliant	Informed	Market Driven	Competitive	Sustainable
63%	16%	13%	7%	0%

Table 7-7 shows the relationship between awareness of TQEM and the respondents' progress towards sustainability. All the respondents who position themselves on the competitive level have experienced TQEM or linking TQM and EM for 7–10 years. The market driven level appears to comprise contractors who are less experienced with TQEM for 1–3 and 4–6 years. Many of the respondents who indicated 1–3 years' TQEM awareness are in the informed level. The majority of the respondents are compliant. This indicates that more awareness of TQEM leads to performance improvement towards sustainability, as was hypothesized.

Table 7-7: TQEM levels towards sustainability vs TQEM awareness

			TQEM					Total
			<1	No	1-3	4-6	7-10	
Levels	compliant	Count	7	11	15	0	0	33
		% within TQEM	100.0%	100.0%	65.2%	.0%	.0%	66.0%
	informed	Count	0	0	6	0	0	6
		% within TQEM	.0%	.0%	26.1%	.0%	.0%	12.0%
	market driven	Count	0	0	2	5	0	7
		% within TQEM	.0%	.0%	8.7%	100.0%	.0%	14.0%
	competitive	Count	0	0	0	0	4	4
		% within TQEM	.0%	.0%	.0%	.0%	100.0%	8.0%
Total		Count	7	11	23	5	4	50
		% within TQEM	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

7.6 Barriers

With the majority of the respondents still at the compliant level, as seen in the previous section, this section investigates the reasons and difficulties that have led to such results. The responding contractors indicated that the reasons are mainly poor organisational design, little implementation of TQM and little awareness of potential synergies. The questionnaires also reported that learning in environmental management programs was unrelated to the existence of a TQM program. Moreover, one manager respondent perceived that the demands of consumers and the public were different thus prompting separate programs to better address the needs of each. However, the main barriers for TQEM effective integration towards sustainability from the respondents' point of view are the absence of TQEM implementation framework (65%), the lack of senior management commitment (23%), and the difficulties associated with implementing EM (20%). 20% pointed out the limited time and resources (Table 7-8).

Table 7-8: TQEM barriers

TQEM Barriers						
No difficulties	Senior management commitment	No clear implementation framework	EM Implementation	No customer demand	Limited time & resources	Measuring Performance
10%	23%	65%	20%	10%	20%	10%

Table 7-9 shows the proportions of TQEM barriers experienced across the respondents' construction sectors. The majority of the housing contractors who responded to the survey indicated that the lack of implementation framework and the integration of environmental management are thee main barriers for TQEM. The absence of TQEM implementation framework appears to be pointed out by the majority of the respondents throughout all the sectors. Therefore, the demand for TQEM should be supported by a framework for implementation.

Table 7-9: TQEM barriers across the respondents' construction sectors

			type						Total
			Housing	Infrastructure	Other	Non-housing	Repair and Maintenance	Different market segments	
difficulties	No difficulties	Count	0	0	0	0	0	5	5
		% of Total	.0%	.0%	.0%	.0%	.0%	11.6%	11.6%
	management commitment	Count	4	1	0	1	0	6	12
		% of Total	9.3%	2.3%	.0%	2.3%	.0%	14.0%	27.9%
	lack of clear framework for implementation	Count	8	0	6	5	5	8	32
		% of Total	18.6%	.0%	14.0%	11.6%	11.6%	18.6%	74.4%
	the implementation of EM	Count	8	1	0	1	0	0	10
		% of Total	18.6%	2.3 %	.0%	2.3%	.0%	.0%	23.3%
	No customer demand	Count	0	0	3	0	2	0	5
		% of Total	.0%	.0%	7.0%	.0%	4.7%	.0%	11.6%
	Limited time and recourses	Count	3	1	3	1	2	0	10
		% of Total	7.0%	2.3%	7.0%	2.3%	4.7%	.0%	23.3%
	difficult to measure the performance	Count	1	2	0	0	1	1	5
		% of Total	2.3%	4.7%	.0%	.0%	2.3%	2.3%	11.6%
Total		Count	12	2	6	5	5	13	43
		% of Total	27.9%	4.7%	14.0%	11.6%	11.6%	30.2%	100.0%

7.7 TQEM related systems

Contractors' obtaining IS9001 and ISO 14001 certifications are expected to have both the motivation and the means (i.e. QMS, EA as discussed in Chapter Four) to improve their performance. Therefore it is worthwhile to assess whether the contractors are accredited or are addressing any individual quality or environmental management systems. This is mainly because the input assessment of corporate-level TQEM primarily deals with the contractors' management capability, organisation capacities and communication issues (Chapter Four). The implementation of the systems mentioned in Table 7-10 would have probably brought certain improvements to the above aspects.

The majority of the respondents seem to seek the accreditation of several quality and environmental systems given by standards such as ISO9001, ISO14001, EMAS and BS (Table 7-10). The ISOs series appear to be the most popular to the respondents. Table 7-10 illustrates the significant trend to register for ISO 9001 with 40% compared to ISO 14001 with 20% only. The ISOs are only separated supporting systems for TQEM employment. The benefits that may have been experienced through linking TQM and EM separate systems are highlighted in the next section.

Table 7-10: Construction companies and the standards

Accredited					
ISO:9001	**ISO:14001**	**BS**	**EMAS**	**None**	**Other**
40%	20%	0%	3%	0%	3%
Addressing					
ISO:9001	**ISO:14001**	**BS**	**EMAS**	**None**	**Other**
37%	27%	3%	0%	7%	6%

7.8 Key Benefits

The previous section shows that contractors appear to be more committed to their own management and control after the implementation of management and environmental related systems. The questionnaire investigates the key benefits of implementing separate TQM and EM systems (Chapter Four) including decreased costs, improved long-term position, increased customer focus, and process productivity. As seen in Table 7-11, when asked to mark as applicable a wide range of TQEM benefits, cost saving (57%), performance measurement (50%), and customer satisfaction (43%) had the highest responses as the main benefits experienced out of implementing TQEM related systems.

Table 7-11: The benefits realized as a result of TQEM implementation

Benefits from TQEM						
Cost Saving	**Customer Satisfaction**	**Market recognition**	**Increase Efficiency**	**Competition**	**Productivity**	**Measuring Performance**
57%	43%	23%	23%	20%	7%	50%

Table 7-12 illustrates some of the important benefits associated with the TQEM awareness. Respondents appear to take 1–3 years TQEM awareness before realizing cost benefit. Yet the market recognition and measuring the performance benefits have experienced by the respondents who has been aware of TQEM for less than 1 year. By

Table 7-12: The benefits realized as a result of the TQEM awareness

			TQEM					Total
			No	<1	1-3	4-6	7-10	
TQEM benefits	cost saving	Count	0	1	18	5	4	28
		% within TQEM	.0%	7.7%	30.0%	22.7%	17.4%	
	customer satisfaction	Count	0	0	13	5	4	22
		% within TQEM	.0%	.0%	21.7%	22.7%	17.4%	
	Market recognition	Count	11	7	6	4	4	32
		% within TQEM	68.8%	53.8%	10.0%	18.2%	17.4%	
	Increase efficiency	Count	0	2	8	0	2	12
		% within TQEM	.0%	15.4%	13.3%	.0%	8.7%	
	competitiveness	Count	0	0	5	2	3	10
		% within TQEM	.0%	.0%	8.3%	9.1%	13.0%	
	productivity	Count	0	0	0	1	3	4
		% within TQEM	.0%	.0%	.0%	4.5%	13.0%	
	performance measurement	Count	5	3	10	5	3	26
		% within TQEM	31.3%	23.1%	16.7%	22.7%	13.0%	
Total		Count	16	13	13	22	23	134

By leaving a space for contractors' comments on this, the questionnaires identified other specific benefits pointed out by a few respondents, i.e. adding value, energy efficiency and waste minimization. TQEM framework for contractors should concentrate on the issues that add value and fit to purpose for construction.

7.9 The Demand for TQEM throughout the Construction Stages

The adoption of environmental practices and TQEM has been viewed from a legal perspective. Nonetheless, a fundamental goal for TQEM integration is uncovering TQEM demand across the construction cycle. When asked about the demand of TQEM across the construction cycle, 36% of the respondents indicated that TQEM could be addressed for the preconstruction stage (i.e. tendering, planning permission, and design purposes). This is due to the new environmental building regulations i.e. part L, as energy efficiency plans is required now for getting a planning permeations.

21.8% suggested that TQEM is important during the construction performance (i.e. controlling noise, waste minimisation, and construction technology). 19% of the respondents indicated that TQEM should be considered throughout the construction supply chain (i.e. construction performance and procurement) (Table 7-13).

Table 7-13: The demand for TQEM

TQEM demand across construction stages					
No Demand	Design & Preconstruction	Construction processes	Post Construction	All Construction Supply Chain	Other specific activities
0%	36%	22%	6%	19%	17%

Table 7-14 shows a cross-tabulation between TQEM awareness and the demand for TQEM across construction stages. Out of the contractors who indicated less than one year's awareness of TQEM, one pointed out the demand for TQEM in the design and preconstruction stage and the rest reported specific practises in the open space provided, i.e. recycling, waste minimization, and energy efficiency. The majority of the contractors who indicated 1–3 years' awareness reported the demand of TQEM in the design and preconstruction stage. The TQEM demand in preconstruction stage and the whole construction supply chain were reported by those respondents with 4–6 years' TQEM experience. The majority of 7–10 TQEM respondents pointed out the demand for TQEM throughout the whole construction supply chain. This indicates that the awareness of TQEM may emerge out of contractors' specific environmental practices then expand to the design and preconstruction stage before covering the whole construction cycle with longer TQEM experience.

Table 7-14: TQEM awareness vs the demand for TQEM across construction stages

			TQEM					Total
			<1	No	1-3	4-6	7-10	
Construction stages(a)	design & preconstruction	Count	1	1	11	3	3	19
		% within TQEM	25.0%	100.0%	34.4%	42.9%	37.5%	
	construction processes	Count	0	0	8	1	2	11
		% within TQEM	.0%	.0%	25.0%	14.3%	25.0%	
	post construction	Count	0	0	5	0	1	6
		% within TQEM	.0%	.0%	15.6%	.0%	12.5%	
	all supply chain	Count	0	0	5	3	5	13
		% within TQEM	.0%	.0%	15.6%	42.9%	62.5%	
	other	Count	3	0	3	0	0	6
		% within TQEM	65.0%	.0%	9.4%	.0%	.0%	
Total		Count	4	1	32	7	11	52

7.10 Performance Measurement

The previous section showed that contractors today are experiencing increased demand for enhancing TQEM. Theses demands go beyond project quality, which was the focus of the TQM movement of the 1980s, and now encompass other areas such as EM and social responsibility. The survey has shown a shift from a regulation-driven, reactive approach to a proactive and beyond-compliance strategy towards sustainability, which requires new indicators for measuring contractors' performance. This section investigates the key performance indicators (KPI) associated with TQEM.

When asked their opinion on which performance measurements are found to add value to their business, the majority of the respondents' emphasise the importance of external feedback on client satisfaction, with 47% claiming the importance of customer satisfaction to winning further contracts, improving their performance and adding value to their business. The internal business perspective refers to the financial measures that contractors use mainly for performance measurement and adding value to their business. 19% of the respondents claim considering some sustainable performance indicators (Table 7-15).

Table 7-15: Measuring construction companies TQEM performance

External stakeholder satisfaction perspective	**Knowledge and skills perspective**	**Internal business perspective**	**Sustainability perspective (social, environmental, accounting indicators)**	**Other**
47%	17%	32%	19%	8%

As can be seen in Table 7-16, of the respondents who indicated awareness of TQEM, the longer the respondents have been aware of TQEM, the greater their key performance over all the given perspectives. The respondents who have been aware of TQEM for less than 6 years appear to measure their performance based on mainly external stakeholders perspectives (which reflect the client requirements importance for winning further contracts) and internal business perspective (which is mainly about generating profit). Yet, the knowledge perspective reflects the importance that should be given to staff training and developing TQEM corporate culture. The knowledge and skills perspective illustrates the percentage of contractors influenced by the current trend of the skill shortage discussed in Chapter Two.

Table 7-16: TQEM and respondents KPI

			TQEM				Total
			No	1-3	4-6	7-10	No
Contractors KPI(a)	External stakeholder	Count	1	14	5	4	24
		% within TQEM	20.0%	37.8%	62.5%	36.4%	
	knowledge & skills	Count	0	3	1	3	7
		% within TQEM	.0%	8.1%	12.5%	27.3%	
	Internal business	Count	1	14	1	1	17
		% within TQEM	20.0%	37.8%	12.5%	9.1%	
	Sustainability perspective	Count	0	6	1	3	10
		% within TQEM	.0%	16.2%	12.5%	27.3%	
	Other	Count	3	0	0	0	3
		% within TQEM	60.0%	.0%	.0%	.0%	
Total		Count	5	37	8	11	61

7.11 The Survey Key Findings

The survey revealed the underlying assumption that there is demand for TQEM framework for D&B contractors in general and in certain construction stages in particular. The survey demonstrates that TQEM could be implemented for contractors the same way they approach TQM. According to the survey, the benefits experienced from employing separated systems, environmental and quality related, present TQEM potential role to contractors' performance improvement.

The survey findings support the points discussed in Chapter Two. The government is encouraging, as a regulator and major client of the industry, more environmental practices and is promoting social and economic priorities, including improved construction quality, safety, health, and the environment, as the *Modernizing Construction Industry Report* (2005) affirms. The principle goals of construction industry development, discussed in Chapter Three, provide a synthesis review of progress, challenges, and opportunities.

Against this background the barriers for TQEM are tremendous, as the survey finding indicated in Chapter Seven. The survey pointed out the most important paradoxes and problems associated with the development and implementation of TQEM. The industry performance in the UK is inextricably linked to a range of factors, discussed in Chapter Three, including: a) The structure of the industry with its fragmentation, complexity and the projects unique nature, b) the skills gap, and, not but least, c) the disparate nature and capability of the public and private sector client base. Anticipated investment growth presents both challenges and opportunities. Realization of this growth in spending requires accelerated development and a concentrated focus on sustainable empowerment to create TQEM supply capability at all levels. Essential, too, is the overhaul of outmoded procurement and delivery systems that are already strained.

The survey affirms that the shortcoming of not developing a formal TQEM framework for identifying and prioritizing client's requirements need to be addressed in order to ensure that quality and environmental standards are clearly defined at an early contract stage. Based on this study's statistical data, conducted 2006–2007, the findings are organized under the inter-related themes of growth, quality/environmental delivery, performance, capacity, and empowerment. With regard to performance, the survey illustrates the following findings on the subjects of the environment, sustainability and quality:

Environment: The TQEM survey highlights the limited awareness of environmental aspects of construction design and performance. It was evident that the impact of design and construction on the environment is not yet a major factor in the delivery of value to clients, i.e. on waste, and the use of water and energy.

The survey indicates that despite isolated respondents' examples of improvement there is very limited commitment to comply with basic environmental requirements. Construction companies' managers appear to view EM as a cost in the system. Aside from the direct compensation and taxation costs associated with their environmental impacts, contractors have to deal with the costs to the economy which are immense and include rework, lost time, damage to plant and equipment, disruption and productivity loss.

Quality: The quality of contractors' products and services are rated in the TQEM survey as average to good (but again with variation between firms). Specifically, the survey found that although some well-established contractors are providing high quality levels of service and products, many are with very little environmental accrediting or addressing voluntary standards. Many of these contractors may not be able to provide acceptable environment and quality and a large amount of customer dissatisfaction can be attributed to their performance.

The survey also reveals that much of the industry's activity, however, relies on the minimum level for compliance with quality and environmental regulations. This often manifests in slow delivery, significant rework to rectify defects, and associated materials waste which is built into the tendering and project costs.

Sustainability: None of the survey respondents claimed to have reached a sustainable level in their design or performance. Few companies only appear to understand the link between TQM and EM and its role towards. A sustainable level of TQEM has not yet been achieved in construction industry.

Ideally, construction sustainability, quality, and environmental strategies should be created at the same time in an integrated manner. In practice, the construction industry appears to separate these strategies, if they have any, from their overall business strategy. Boardroom discussions of sustainability issues usually appear to be reactive to 'bad news' (new environmental regulations, taxation, clean up costs and lawsuits). Construction industry quality/environmental managers or manager directors seem to lack the tool to quantify the economic benefits that more productive TQEM can offer. It may be due to only using financial resources for measuring company performance, or lack of interest that makes them unable to determine how their activities can contribute to success.

Although addressing or being accredited to ISO14001/19001 may help to develop a common language, it is not enough by itself. Some contractors appear to approach these systems as a 'ticking boxes' strategy with no effort being given to effectively integrating and enhancing it as a guideline for continuous improvement and competitive advantage. The high response rate indicates that a surprising number of companies in the construction industry feel that they have indeed experienced positive results or are at least curious to know whether or not TQEM can bring them new business opportunities. Thus it is encouraging to note that TQEM awareness has increased dramatically over the past few years, yet the construction industry is still far: from translating this awareness into sustainable competitive advantages, from proactive TQEM approach, and also far from achieving the *Modernizing Construction* report (2005) objectives (Chapter Three).

To conclude, contractors should change their traditional way of dealing reactively with environmental issues. D&B contractors are challenged by determining whether it is better for the firm simply to emphasize compliance or whether the firm wants to become recognized as a leader in the development and application of TQEM based systems. In large part, the failure of contractors' management to become more environmentally committed is really a reflection of its inability to address and resolve these paradoxes. The barriers revealed by the study survey demonstrate D&B contractors' need to enhance a formal TQEM framework. This could be achieved by encapsulating the survey results into key successful factors for TQEM implementation. This will enable TQEM framework to be a value added approach that starts from building a strategy then considers having indicators in all project stages.

7.12 Summary

Up to this point, the research has presented the survey findings on the construction companies TQEM awareness, demand, practices, barriers and the benefits that may occur. It identified the following areas that should be given a high priority: senior management commitment, the need for effective implementation of TQEM, and a simple approach for understanding the concepts.

Overall, the contractors' approach to EM has been shifted to corporate environmental strategy (discussed in Chapter Four). This is reflected in the fairly widespread application of the TQM principles to environment management, referred to as TQEM. The survey demonstrated high awareness of TQEM among the respondents. There is demand for TQEM to improve contractors' productivity, efficiency and reputation. Fundamental to the TQEM philosophy is the idea of systems approach (ISO9001 and ISO 14001) to defect-prevention instead of defect-detection and continuous improvement in all stages of construction to exceed customer expectations. The view that pollution is a defect of the building process and an indicator of waste could lead many contractors to apply the TQEM philosophy to make organisational changes that will enable contractors to progressively eliminate waste and increase efficiency.

The survey noted that most of the respondents rated their performance as far from achieving sustainability. Thus a considerable amount of the respondents selected the market-driven level. This indicates that the response is not only to regulatory requirements, but also is reactive to clients' quality/environmental expectations in terms of providing better operational performance. In general, TQEM appears to be driven by the environmental building regulations. The new voluntary code for sustainable homes introduced by the government takes this approach further in respect to client responsibility. The barriers revealed by the survey demonstrate D&B contractors' demand for a formal TQEM framework. This will be addressed in next chapter by encapsulating the survey results into key successful factors for TQEM implementation. This will enable TQEM framework to be a value added approach that starts from building a strategy then considers having indicators in all project stages.

CHAPTER EIGHT

REFINING TQEM PRIMARY FRAMEWORK

CHAPTER EIGHT: DEVELOPMENT AND REFINEMENT OF TQEM PRIMARY FRAMEWORK

8.1 Introduction

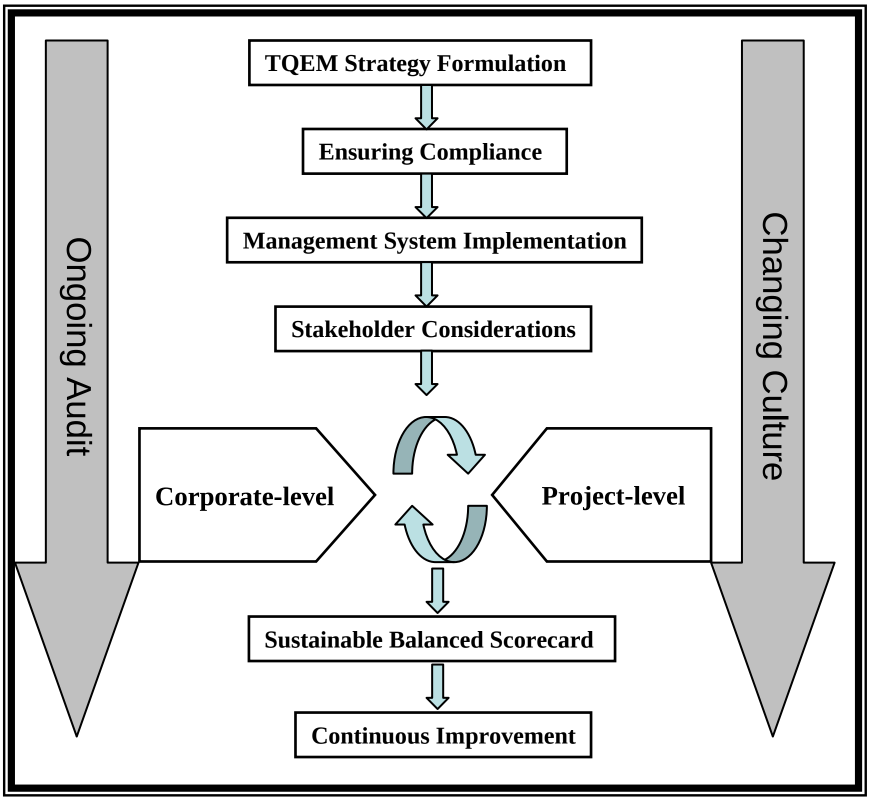
The results of the survey have shown that the move to adoption of environmental business practices and TQEM has been viewed from a perspective heavily influenced by either normative or legal considerations, with some evidence that TQEM can be motivated by the potential for competitive advantages. The challenge is to determine whether it is better for a firm to simply emphasize compliance or whether the firm wants to become recognized as a construction-leader in the development of a TQEM management-based approach.

The survey conclusions validate the hypothesis that TQEM could be implemented in D&B main contractors. The respondents have employed a range of quality and environmental management systems and practices. The benefits experienced include reduction in quality costs, better employee job satisfaction (because they do not need to attend to defects and client complaints), recognition by clients, work carried out correctly right from the start, and closer relationships with subcontractors and suppliers. TQEM performance measures appear to be varied from internal business perspective, external client perspective, and sustainable perspective.

The survey findings confirm the underlying assumption that there is demand for TQEM framework. This framework should consider the three complex issues revealed by the survey: (A) Strategy formulation, (B) changing management for fit to purpose decision making for buildings, and (C) building knowledge and information systems for sustainability triple bottom lines. This section concludes by refining the corporate-level TQEM framework towards sustainability.

Based on the literature review and the survey finding, a primary TQEM framework is developed (Figure 8-1). The framework in this context requires: (i) key mechanisms criteria (shared between TQM and EM), (ii) a level of analysis (corporate-level), (iii) a certain focus (improving contractor quality and environmental performance towards sustainability), and (v) a measurement system. The key areas of TQEM corporate-level could be categorised into six phases. (a) strategy formulation, (b) insuring compliance, (c) management system implementation, (d) TQEM integration, (e) sustainable balanced scorecard, and (e) continual. Based on the literature review and the survey finding, this chapter highlights primary TQEM framework; design criteria, phases, key successful factors, strategic levels towards sustainability, adding value approach, and key indicators.

Figure 8-1: TQEM Primary Framework



8.2 TQEM Framework's 'Design Criteria'

The development of any framework has to start from an initial idea and concept. In the case of implementing TQEM, one can start by trying to analyse the range of options available such as developing a quality assurance system, environmental assessment, an improvement strategy and methodology, etc. The survey revealed the underlying assumption that there is demand for TQEM framework for D&B main contractors in general and in certain construction stages in particular. This section elaborates the chosen approach and sets the framework 'design requirements'.

The role of leadership has been fundamental to the success of any performance-improvement framework, as discussed in Chapter Three. The TQEM framework for the UK construction industry should start from gaining management commitment. Like all reform initiatives around the world, compliance is an important motive for this TQEM framework. It should be dependent to a greater or lesser degree on enforcement and compliance mechanisms. The key areas that make a prominent contribution include:

- Legislation to seek compliance with minimum acceptable standards (such as safety and health, waste taxation and certain environmental considerations),

- Novated D&B procurement instruments, because it allows the contribution made by the principle contractor to mitigate and manage the environmental and quality effects of the construction project through the implementation of a formal TQEM framework. This will be a powerful change compared to other instruments used in previous construction performance improvement initiatives, discussed in Chapter Three. This is due to the fact that novated D&B procurement strategy in this context will affect change amongst suppliers, i.e. clients specifying their requirements (aligned with the framework objectives) for other parties wishing to do business with them often requiring compliance with codes of conduct, standards, and guidelines, or the mandatory use of management systems,

- Registration and accreditation of contractors according to specified criteria for different types of activities – including 'construction registers', which are typically implemented through legislative or procurement means,

- Commitment to voluntary compliance together with review mechanisms, to charters,

- Quality and environmental techniques are key successful factors to support the attainment of framework objectives. Several tools and techniques were discussed earlier in Chapter Two. Many of the environmental and quality systems, outlined earlier in Chapter Four, provide tools together with information to equip various stakeholders for change, and

- Reviewing and evaluating performance for continuous improvement.

The framework allows for phased acknowledgement of TQEM progress towards sustainable competitive advantages. This phased approach allows more focus on TQEM barriers found by this study survey such as; (a) management commitment, (b) limited time and resources, (c) difficulties in implementing the requirements of the standards and (d) the cost involved in integration. The framework aims to:

- Demonstrate a sustainable approach for how and where TQEM fits in construction companies' business.
- Enable compliance with quality/environmental regulations.
- Reduce the TQEM cost by bringing more understanding of the opportunities it brings.
- Increase the return on the environmental investment by capturing these new opportunities.
- Add value to construction companies' business and improve their image.

The barriers revealed by the survey demonstrate D&B contractors' demand for a formal TQEM framework. TQEM framework should encapsulate the survey results into key successful factors for TQEM implementation. This will enable TQEM framework to be a value added approach that starts from building a strategy then considers having indicators in all project stages. Next section offers this study phased approach for refining corporate-level TQEM framework towards sustainability for D&B main.

8.3 Refining TQEM Primary Framework towards Sustainability

To this point, this study has elaborated over the survey results, pointed out some areas overlooked by D&B contractors, and discussed how TQEM framework should address these deficiencies. Based on the survey findings, the following are some of the most important paradoxes associated with the development and implementation of TQEM which will be addressed for corporate-level TQEM framework:

- Top management must be willing to accept and champion corporate formal development of TQEM. However, some of the survey respondents show strong bias in favour of ignorance at the highest levels of the firm. Therefore, there is a demand for developing a formal TQEM framework which starts with developing TQEM strategy discussed is section 8-5.

- The shortcoming of not developing a formal TQEM framework, for identifying and prioritizing client requirements ensures that quality and environmental standards are clearly defined at an early contract stage, will be addressed by this study TQEM framework. By ensuring compliance, and quality and environmental management system implementation, contractor will be able: to clarify clients requirements, to formulate design solutions which satisfy all client needs, to be more cost efficient, and to achieve higher quality and environmental standards.

- TQEM shall demonstrate that being environmentally responsible ultimately makes a company more efficient and more competitive. This study TQEM framework is a new approach that ensures the quality and environment of the end product since the client's requirements are well defined and can be used to check compliance and performance. The clear definition of client requirements at an early stage results in a reduction in uncertainty for all parties to a given construction project.

- In figure 8-1, the proposed strategy, measurement and continuous improvement approach aims to ensure main D&B main contractors capability to meet the built environment needs for development. This potentially will lead to more competitive construction that meets high standards of performance in terms of quality, productivity, safety, and protection of the environment.

Within the context of these goals, TQEM has organised the inter-related objectives of sustainability under the following broad themes geared at fundamental cultural change. The headline objectives for this framework are:

- effective and efficient delivery and procurement with TQEM consideration,

- quality and value for money in relation to value based solutions, whole life quality, project cost, time and quality and appropriate long term relationships as a basis for sustainability,

- sustainable empowerment, growth and capability, which must focus the role of all stakeholders around measures that expand the capacity of industry, and

- respect for the environment and a progressive focus on construction that promotes a sustainable built environment, a sustainable natural environment, and a value proposition that incorporates the cost of non-renewable natural resources in construction, maintenance, and operation.

The interventions to promote these objectives for improved performance builds on the EM & TQM own experience and corresponds with the national experience distilled above, namely:

- facilitation of appropriate leadership by relevant stakeholders in support of the objectives

- awareness creation and promotion of the objectives,

- development and promotion of information and tools to support the objectives,

- capacity building, where appropriate, to facilitate the uptake of the information and tools,

- enforcement and compliance mechanisms, where necessary and appropriate, and

- monitoring, evaluation and review, at the macro and micro-level.

This framework supports structuring the priorities for systematic improvement. The key areas of corporate-level TQEM can be categorised into six phases starting from construction companies' management commitment throughout the following phases: (a) strategy formulation, (b) ensuring compliance, (c) management system implementation, (d) TQEM integration, (e) sustainable balanced scorecard and (e) continual improvement (as can be seen in Figure 8-1) . The framework aims to collect and assist all legislation impacting on the construction industry – which will, amongst others, provide the opportunity to review the current legislation impacting on construction quality and the environment, and to propose appropriate action.

This approach represents the corporate-level TQEM only and should be linked to the construction cycle through the case studies. This TQEM framework, figure 8-1, encapsulates the survey results into key successful factors for TQEM implementation, a value added approach that starts from building a strategy then considers having indicators in all project stages as discussed in the followings.

8.4 TQEM Key Successful Factors

This chapter analyses the survey results in relation to the construction characteristics discussed in Chapter Three. It can be argued that despite a few positive responses, in terms of linking TQEM to the contractors' fundamental performance, it seems that contractors are still far from achieving the UK government's sustainability targets (discussed in Chapter Two). This section attempts to capture the key factors for TQEM framework through linking TQEM elements (revealed by the survey) with D&B contractors' problems (discussed in Chapter Two).

The development of any framework for performance improvement has to start from an initial idea and concept. In the case of implementing TQEM, as can be seen in Figure 8-2, one can start by trying to develop a sustainable strategy to which TQEM contributes. Due to TQEM's role towards sustainability, discussed in Chapter Five, this strategy has the potential to link the social, environmental, and economic perspectives within one framework.

This argument supports using balance scorecards within design and construct procurement route to achieve TQEM strategic objectives, as illustrated by Figure 8-2, TQEM main successful factors could be classified as: adding value, fit-for-purpose and sustainability. The sub-tasks are therefore:

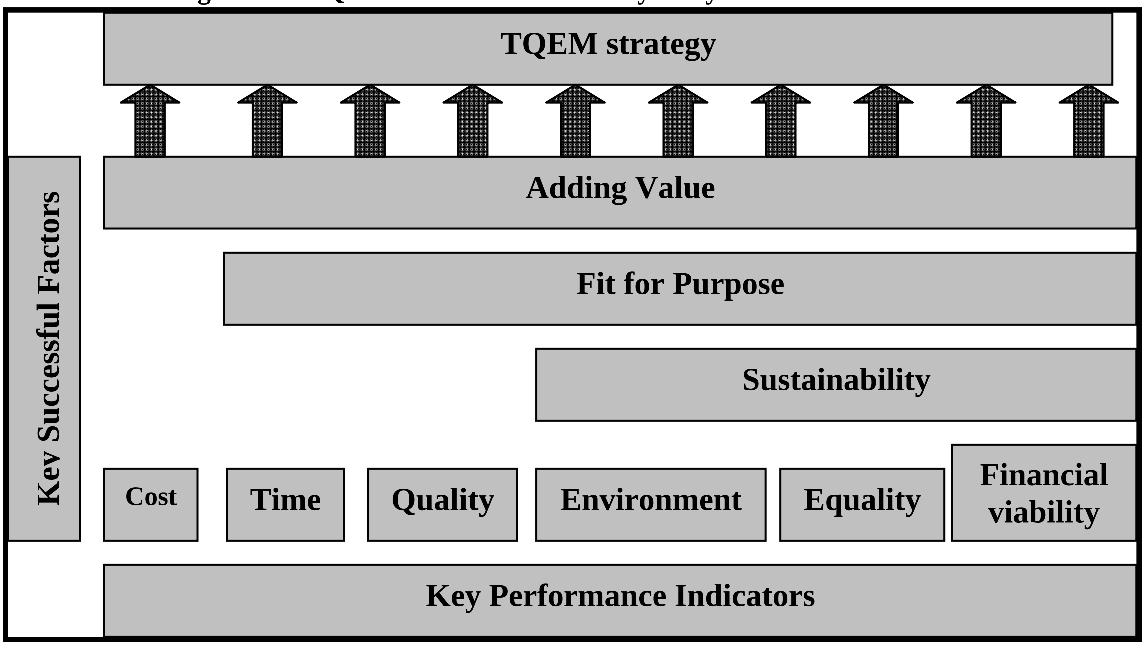
- cost (i.e. project cost and contract cost)
- Time (i.e. project time and contract time)
- Quality (functionality, design impact, construction quality and promoting excellence and innovation)

- Environmental: environmental responsibility, ethical sourcing and health and safety (in scope, design, construction operations, behaviour and culture)

- Equalities: includes promoting equality and diversity, community engagement, supply chain management and employment

- Financial viability: considering management structure and cost benefits (community utilization and benefits)

Figure 8-2: TQEM towards Sustainability - Key Successful Factors



There may be three complex, interconnected factors in making sustainability accessible: (A) Strategy formulation, (B) changing management for fit-for-purpose decision-making on buildings, and (C) building knowledge and information systems for sustainability triple bottom lines. These elements appear to concentrate on changing the organisations internal systems.

By addressing quality management, many environmental management commitments appear due to the shared area and links discussed in Chapter Four (e.g. waste minimization, water reuse, energy efficiency), which were undertaken as quality management activities. They are considered to be market-driven, in contrast to EM, which is considered to be legislation-driven. Such a strategy is not exactly deliberate, but it is certainly internal. Thus, the respondents' approaches appear to pursue the enterprise internal strategy, which is common in the construction industry (Mintzberg.

1998: 23). The discussion in this section has highlighted the key factors of TQEM implementation. TQEM framework should picture the interaction between these key factors on the corporate-level. Hence, to address the perception of a gap emerging from not joining up of the construction cycle with the management-based solutions for environmental performance development, TQEM shall start from building TQEM strategy, adding value, developing TQEM indicators.

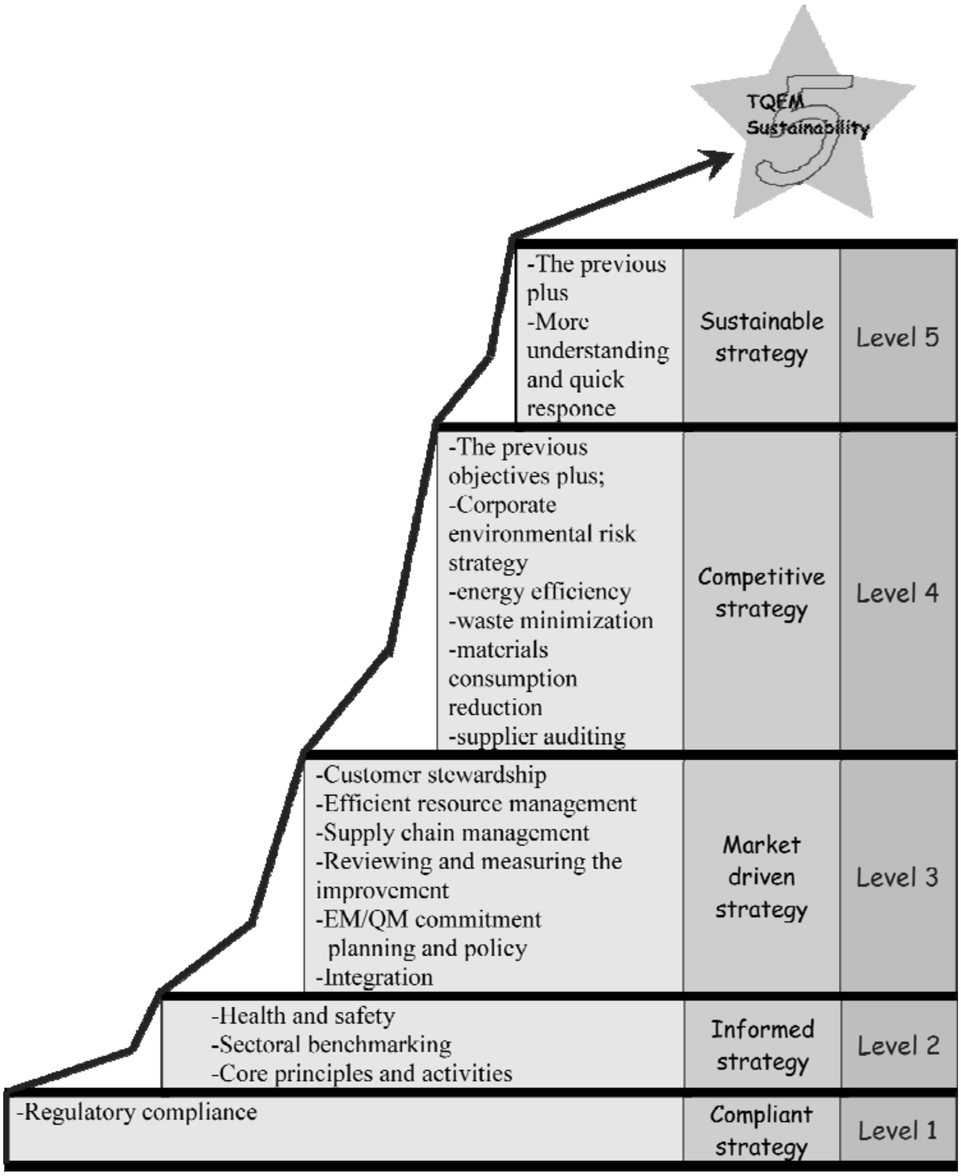
8.5 TQEM Strategic Levels towards Sustainability

After discussing the extent to which the construction industry has enhanced TQEM towards sustainability, this section provides a scale that may help the construction industry position itself on TQEM levels. The five levels used in the survey for classifying contractors’ position towards sustainability were presented in the previous chapter. Figure 8-3 illustrates each level’s objectives and key techniques that may drive the construction industry towards achieving the top level.

The results of this study suggest that most of the construction companies are still at the compliance level, accompanied by a demand for TQEM in their activities. At this level TQEM is viewed as a cost to most companies driven by regulations. As an organisation gains a level, more benefits result. For instance, the finding of a relatively high percentage in cost saving benefits indicates that companies have experienced some benefits directly from TQEM, such as waste minimization and energy efficiency.

Few construction companies have achieved level 3 by having a market-driven strategy. For example, some companies have integrated pollution-prevention, resulting in additional customers and new market considerations into their operations and product design and development functions. That has led to cost-saving and cost-avoidance and has encouraged the seeking of ways to achieve competitive advantage through TQEM.

Figure 8-3: TQEM strategic level objectives



In the level 4, the interviews with the two companies present at this level in the responses show that these companies have realized revenue-generation through TQEM. The level five strategy, however, appears to evade to the UK construction sector. Evidence in the literature can be found to suggest that sustainability appears to be difficult to understand for most companies. The results support the hypothesis that construction companies are still far from achieving sustainability. Hence, the growing pressures of regulation on organisations to take greater environmental responsibility support the Porter hypothesis that sustainability legislation is the first driver to SD opportunities, as discussed in the literature review. Building on the UK construction sector characteristics, discussed in Chapter Three, level 5 requires a sustainable elaborating strategy. Table 8-1 provides the main objectives for the five stars strategy as gathered from the survey results and literature findings.

Table 8-1: Level 5 main objectives

Economic Issues	Environmental Issues	Social/Ethical Issues
▪ Technology feasibility ▪ Financial feasibility ▪ Short and long term profitability ▪ Adequate pricing	▪ Waste minimization ▪ Clearer construction ▪ Clearer materials ▪ Eco-efficiency ▪ Less materials ▪ Less energy ▪ Renewable resources ▪ Renewable energy ▪ Recycling	▪ Fair trade ▪ Equitable policies ▪ Good employment ▪ Conditions of work ▪ Investment in communities ▪ Support for regional economy ▪ Cruelty-free ▪ Sustainable of real needs ▪ More customer value ▪ Better systems ▪ Participation ▪ Equality

The sustainable level 5 strategy, Table 8-1, should include:

- Addressing construction economical, social, and environmental concerns proactively.

- Understanding sustainability concept, threats, and opportunities. Using SWOT analysis as a way for learning more about their internal strength, weaknesses, as well as external opportunities and threats. Furthermore, customer and market research and networking are a useful method for greater understanding.

- Having understood in which TQEM level they operate, their strengths, weaknesses, threats and opportunities, construction companies have to respond in areas such as developing new product and finding new market, reporting, co-operation with society to find solutions to environmental problems, and research and development.

After studying the current situation, to bridge the gap between the current position in the TQEM levels and level 5, a five star strategy's objectives should be formulated to drive the management systems, techniques and programmes required to integrate TQEM, as discussed in the final chapter. Further, many TQEM systems and techniques can be found in the literature review. The results indicate that the ISOs have been widely accepted among construction firms. Interestingly, the interviews with some companies that do not address ISO14001 show that ISO9001 is believed to be market-driven and to positively affect the business bottom-line. Many environmental applications, however, can be found due to the shared outlines between the two standards e.g. waste minimization and energy efficiency.

Other contractors, who are accredited to ISO19001, are still acting reactively. This highlights the need for an innovative TQEM approach. Further, using TQEM may be the appropriate management system for level 5 TQEM. It will ensure the inclusion of issues beyond compliance, such as health and safety, economical and environmental aspects, as well as making use of the manufacturing sector experience in TQEM techniques to empower their TQEM similarly in terms of TQEM considerations in decision making.

In addition, the literature in this area is awash with techniques that support TQEM system, such as risk management, LCA, DFE and SPD. The results show that only a few construction firms who have experience at level 3 and have selected the market-driven strategy are striving for more effective implementation for the techniques. LCA sounds complicated, time-consuming and demanding of resources. Others have considered DFE in specific activities associated with their industry's need. It can be argued that level 5 may enhance sustainability as the main technique.

To conclude, TQEM framework shall start from building TQEM strategy. This is because contractors' innovation, flexibility and willingness to change should be utilized within a sustainable approach for integrating TQEM. Hence, to steer their business towards sustainability and capitalize on TQEM, construction firms need to step back, view their position, then take a brave shift to the five stars level of TQEM. This involves agreeing on TQEM strategy as a first phase in TQEM framework. Yet, the level of TQEM strategy has to fit to purpose and add value to contractors, as explained in the following section.

8.6 TQEM, Adding Value Approach & Fit to purpose

In order to go beyond the compliance level towards a more sustainable approach, TQEM framework has to translate environmental legislation into sustainable competitive advantages. The analysis in this section is involved in overcoming the TQEM barriers revealed by the survey.

As the survey results show that many respondents have been accredited to ISO: 14001. A number of them have published reports that quantify significant improvement in areas such as site clean-up, waste reduction, health, and safety. Additionally, many general managers lack understanding of sustainability and TQEM concepts and tools.

The literature review highlights that good TQEM practice is both good for the environment and for business. This view is critical for companies seeking to justify these developments to managers and stakeholders who have more narrowly defined views. In other words, being able to integrate environmental issues in business terminology may provide these issues with better chance of motivating decision-makers to act.

To achieve level 5 TQEM strategy (discussed in the previous section), TQEM should make sense to construction business. Companies' senior managers need to understand TQEM sustainability. In turn, TQEM needs to speak in a business language. The survey results indicate that contractors' culture seems to favour decision-making criteria based on financial measures. To overcome this barrier; TQEM framework should involve in the following critical areas, illustrated in figure 8-3:

1.) Stakeholder value: Stakeholder value stems from TQEM through getting employees loyalty, innovation and commitment as well as customer satisfaction and recognition and shareholder trust.

2.) Environmental value: Should be linked to the core business decision making and play its role as one of business's sustainability bottom line measures. Health and safety for example adds environmental value by being responsible about construction operations impact. Consequently, social value is enhanced by stakeholder satisfaction. The economical value associated with image and value created is also evident.

3.) Economic value: In terms of environmental return on investment, it can be argued that the economic and environmental considerations can be integrated at the decision-making level. Environmental risk, benefits, investment, and time requirements should be quantified and reported to the board.

4.) Product life cycle impact: TQEM should be integrated in the product function from the concept stage, design, development and distribution and end life cycle. Effectively adapting LCA may enhance sustainability in the product function.

5.) Operations efficiency: Contractors can contribute to sustainability by improving their operations and functions in terms of input, output, and process. Energy efficiency, waste minimization, pollution prevention have been adopted by many construction companies.

6.) Demand Side Impact: Some authors argue that customer demand for sustainable construction has dramatically improved opportunities for opening new business, new markets and more competitive advantages in the last few years (Porter & Linde, 1995). Thus increasing stakeholders' awareness of TQEM is vital for successful integration. In turn, TQEM can play a role in demonstrating the opportunities in capitalizing through sustainable practices (Figure 8-4) that requires participation from all construction stakeholders.

TQEM framework should start from clarifying the concepts through sitting vision, values, and ethics. Adapting five stars strategy may be an effective way to capitalize on the sustainability of environment. The construction industry's traditional mindset of dealing with environmental issues as a cost should be shifted to adding value, improving contractors' image and delivering innovation towards sustainability. Sustainability means responsibility for a better economical, environmental, and social future.

Figure 8-4: Sustainability of TQEM

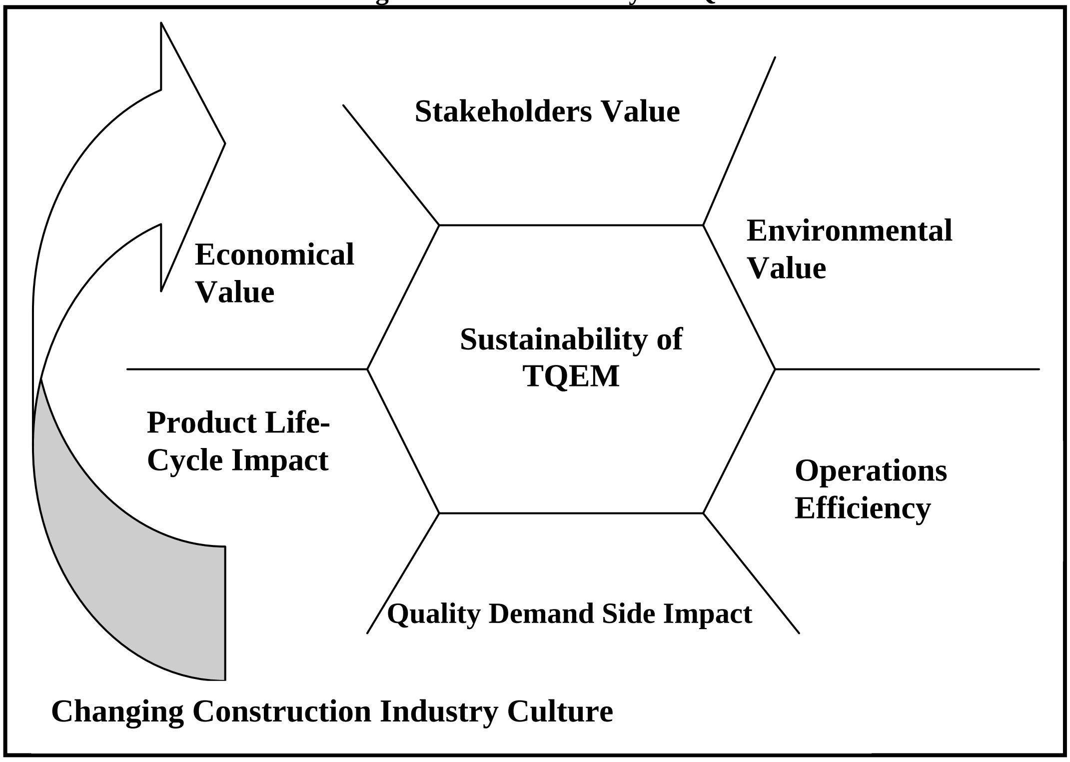


Figure 8-4 illustrates the importance that should be given to developing a strategy for TQEM framework implementation. Then, the framework should include planning and preparation of a document detailing the way forward. Sustainable strategy that enhances quality and environment planning requirement is required. Hence, this strategy should be supported by TQEM key indicators on the corporate and project levels.

8.7 TQEM Key Indicators

As discussed in Chapter Three, in both manufacturing and construction work environments, the quality and environment of work is formed by (i) the end product or service, (ii) all the transformation processes, and (iii) the inputs used to provide the final goods and services. The distinctions between the product, the service and the processes that transform resources into value are ambiguous in the construction environment (Hassan, 2006; Arditi *et al.*, 2002). In an attempt to eliminate this ambiguity, this research presents a comprehensive view of TQEM that deals with performance indicators on both corporate-level (business related aspects of planning and decision making) and the project-level (procurement and performance in terms of design and construction). The corporate level includes establishing a corporate TQEM culture in the contracting company that influences all the parties involved in a construction project.

8.7.1 TQEM Indicators at the Corporate-Level

TQEM indicators at the corporate level are the processes an organisation uses to achieve TQEM on the business levels. The survey has identified certain key areas at the corporate-level. Management commitment, decision making criteria, financial analysis, and cultural aspects are the main attributes of TQEM strategy.

The corporate TQEM culture is a critical player in achieving client satisfaction. TQEM framework should start with capturing clients' requirements in terms of quality and environmental issues. On the other hand, suppliers and subcontractors should comply with the main contractor's TQEM framework to win the work and develop potential partnerships.

In Chapter Three, the mechanisms that provide control over the construction processes were discussed. A most prominent example of TQEM-related frameworks for quality, environment, sustainability, and management are the Malcolm Baldridge National Quality Award in the USA, the International Deming Prize, and CEEQUAL award in the UK. The survey illustrates a significant implementation of the ISOs which could be extended for more TQEM practices. The ISOs series of standards, discussed in Chapter Four, are environmental and quality system standards that guide a company's performance of specified requirements in the areas of design/development, production, installation, and service. They presume that certain generic characteristics can be standardized, and that a well designed, well implemented, and carefully managed quality system provides confidence that the outputs will meet customers' expectations and requirements.

These systems require the supplier to have a verifiable process in place to ensure that it functions consistently. They are the cornerstones of a successful TQEM system, and are representative of the general characteristics of a TQEM-conscious organisation. It is anticipated that their existence in a construction company should increase client satisfaction by providing an infrastructure for quality improvements in company operations. They create the quality vision of the contractor organisation at top management levels.

8.7.2 Project-level TQEM

The survey gave an introduction to the project-level TQEM's indicators which require further study in the case studies. The output of a construction project includes the finished facility and the contracting service. A complete description of TQEM project-level quality requires an in-depth view at both construction performance and procurement. In this study, the constructed facility constitutes the product of the construction project. The transformation process from resources to the constructed facility is referred to as the contracting service. The constructed facility and the contracting service form the construction project. The customer satisfaction experienced with the constructed facility and the contracting service defines project-level quality in construction.

This study suggests that TQEM in construction projects includes a mix of product and service TQEM dimensions. The service TQEM dimensions may be easily interpreted as they are directly associated with contracting services. The product TQEM dimensions are associated with the construction product, i.e. the constructed facility. The interrelationships between the design and the delivery of construction products and services impede defining quality dimensions in precise terms. The elements of the project TQEM process of the design and delivery systems are not always as visible to the end-users as they are to the contractor.

To be able to define these elements in a construction project, a results-oriented approach may be useful. This is where the dissection of the construction client into the owner and the end-user is employed. It is assumed that the product TQEM dimensions are mostly associated with the end-user, whereas the owner is the most direct recipient of all service TQEM processes. In some cases the owner and the end-user are the same entity. When they are not, the product and service quality dimensions reflect the perceptions of the party that most directly experiences the product or the service associated with the construction process.

It is expected that a contractor will conform to minimum requirements in all dimensions of project TQEM while excelling at some, based on its past experience and core competence. In other words, it is not possible for a contractor to perform flawlessly in all these dimensions. Yet, minimum requirements set for each of them will help eliminate the ambiguity over what level of TQEM is expected from the constructed facility or from the contracting service. This will also create a benchmark for comparing the contractor's performance in each dimension, while creating a universal scale of measurement. The dissection of the construction project into its product and service components facilitates the identification of quality traits in the construction project. The product and service TQEM dimensions create a framework that provides a clearer understanding of project TQEM.

The TQEM-related decisions of the client have to be made prior to the start of construction, because they set the tone for the type and function of the construction. Scope definition and briefing are the phases of the project where the client shapes his/her needs and expectations. The design quality, although not an easy concept to define, is the responsibility of the design team whether it is an independent consultant, in-house design group within the contractor's company or within the client's organisation.

8.8 Summary

The survey findings illustrate the demand for a formal framework for TQEM and suggest extending TQEM processes over the project development stages. With the increasing the environmental regulation on contractors, if EM and TQM systems are not integrated and maintained effectively, contractors may find themselves being channelled into managing the documentation aspects of the certification process, rather than achieving the objectives of the improving quality and environmental performance.

The primary TQEM framework developed in this chapter would hopefully be sufficiently general for implementation purposes. TQEM framework phases demonstrate; a) TQEM evaluation, undertaken by the contractor organisation (strategy formulation), b) the contribution made by the principle contractor to mitigating and managing the environmental effects of the construction project through management system implementation, and c) the translation of TQEM into management procedures and working instructions for use on the site to ensure environmental and quality control of site works.

The discussion in this chapter has pointed out the levels of TQEM towards sustainability, TQEM adding value approach, and TQEM key successful factors. The proposed framework centres on six phases starting from management commitment throughout the following phases: (a) strategy formulation, (b) ensuring compliance, (c) management system implementation, (d) TQEM integration, (e) sustainable balanced scorecard, and (e) continual improvement. This framework still needs to be linked to the construction cycle. Understanding the case studies' informants' professional standing and the significance of their comments are enhanced to ensure the primary TQEM framework external validity. The framework is developed further through the provision of rich, thick detailed description out of the case studies which allow any other D&B contractor interested in transferability to have a solid framework for comparison.

CHAPTER NINE

CASE STUDIES FINDINGS

CHAPTER NINE: CASE STUDIES FINDINGS AND PRIMARY FRAMEWORK VALIDATION

9.1 Introduction

The deployment of TQEM provides a sound foundation for sustainability vision and principles for D&B main contractors. Hence, in practice, project-level TQEM has to be established and linked to the previously developed corporate-level TQEM. As explained in Chapter Six, the study combines two phases of investigation (survey and case studies) for two main reasons: 1) The two different methods are used for different purposes as the survey focuses on corporate-level TQEM while the case studies concern with the project-level TQEM, and 2) this use of multi-methods enables triangulation to take place in order to ensure the data validity.

The second phase of the investigation involves in three case studies. The case companies are three main reputable D&B contractors. Understanding the case studies' informants' professional standing and the significance of their comments are enhanced to ensure the primary TQEM framework (Figure 8-1) external validity. The framework is developed further through the provision of detailed description out of the case studies which allow any other D&B contractor interested in transferability to have a solid framework for comparison.

The purpose of the case studies is to understand TQEM possible impact on different aspects associated with contractors' performance and procurement. The primary TQEM framework will be tested and linked to the project phases. The intention is to validate the concepts presented in the primary framework through open-ended questions. The contractors are then asked to give their comments on the feasibility, the ease of implementation, the overall structure of the framework.

The case studies protocol was discussed in Chapter 6. Robson (2002: 178) defines case study as "a strategy for doing research which involves an empirical investigation of a particular contemporary phenomenon within its real life context using multiple sources of evidence". This strategy is of particular interest to this study for gaining a rich understanding of managers' opinion on integrating TQEM into the construction processes. Interviews, observation and document analysis are included in the study protocol. This chapter starts from the content frame and interviewee coding. Each case (background, major aspects of implementation and implementation framework) are highlighted based on the company's documents and managers' perspectives in relation to four key TQEM principles (management and leadership, continuous improvement, quality and environmental systems, and implementation aspects). Finally, the primary TQEM framework (Figure 8-1) validity is investigated.

9.2 Content Frame and Coding

Coding means; categorizing segments of data with a short name that summarizes and accounts for each piece of data (Charmaz, 2006: 43). It provides the pivotal link between collecting data and developing an emergent theory to explain these data (Gomm, 2008: 301). This section highlights the case studies approach to interview coding and content analysis.

While the survey investigated corporate-level TQEM, the case studies aim to examine project-level TQEM, the validity of the proposed framework, and linking TQEM with the procurement and construction cycle. This requires deep analysis at organisational or collective levels of analysis to reflect assumptions, actions, and imperatives that frame action. The basis on which case studies' performance towards TQEM is judged are: a) tope, middle, and project levels managers and decision makers' opinions, b) quality, environmental and sustainable related document analysis, c) observations at the company premises and D&B project sites.

The primary strategy utilized in this study to ensure the primary TQEM framework external validity will be the provision of rich, thick detailed description out of the case studies so that any other D&B contractor interested in transferability will have a solid framework for comparison. The three cases are reputable D&B main contractors. In other words, all cases studies have an extensive experience in being contracted by a client to manage the design and construction processes. Therefore, the study will not only benefit from the case studies extensive experience with D&B but also from the experienced decision makers interviewed.

In each case study, the interviewees were coded as shown in Table 9-1. The comments included in the case study results and cross-case examination chapters are referenced accordingly. Studying these codes allows developing deeper understanding on current contractors' practices and its implication for quality and environmental performance. Case studies informants include:

- Case study A: within this specialist contracting company three informants were interviewed. The chief exhibitive 'C', the MD and quality manager 'Q' (who is responsible for quality-environmental-safety assurance plans), and one project manager were interviewed.

- Case study B: in this general construction company, the interviews were conducted with the company head of sustainable development department 'S', one of the company project managers 'P', and two representatives from BRE -the company strategic partner- (the whole life cycle champion 'E', and innovation champion 'I'). 'P' here had a QA training to be certified for 'Q' role on the project-level.

- Case study C: in this general construction company, the company quality manager 'Q' and two experienced project managers 'P' were interviewed. Some of the interviews were held on one of the company novated D&B project work site.

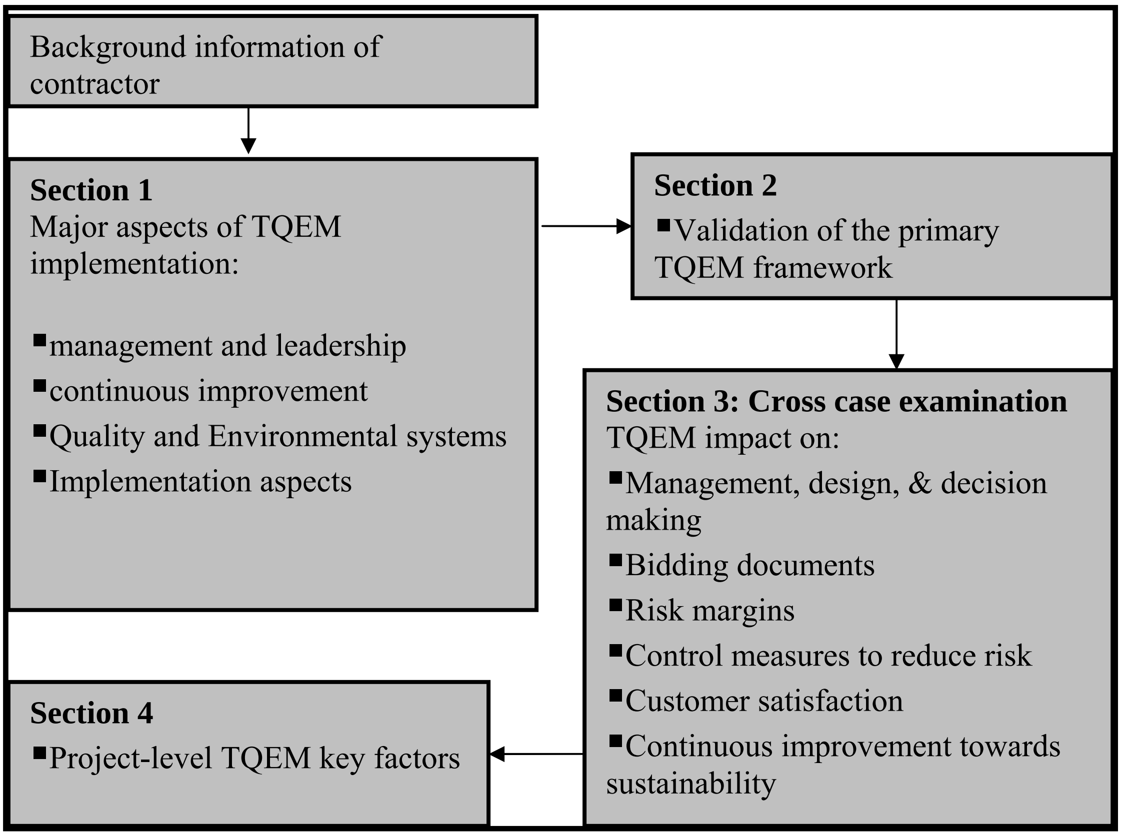
Table 9-1: Interviewees Coding

Coding of interviewees for the case studies	**Code**
Main contractors exhibitive	C
Quality manager, MD or system manager	Q
Environmental manager or Whole life value champion	E
Innovation champion	I
Sustainability manager or sustainability champion	S
Project manager	P

For this study, informants' anonymity is combined with other ethical consideration. The following safeguards are employed by this research to protect the informant's rights: 1) a cover letter was sent to the interviewees to articulate the research objectives and to include a description on how the requested data will be used (Appendix A), 2) emailed permission to proceed, with interviews, document analysis, and field observations, were requested from informants, 3) the informant are informed off all data collection methods and activities, 4) the interviews transcriptions, written notes , interpretations, and reports will be made available to the informants.

As can be seen in Figure 9-1, the areas for exploration with interviewees and document analysis are: a) How the company has approached TQEM, b) Why the company has chosen the particular approach, and c) How the framework management phases can be linked to construction cycle and procurement strategy. The main contractors were asked to give their comments on the feasibility, the ease of implementation, and the overall structure of the framework. The intention is to validate the concepts presented in the framework (Figure 8-1) through open-ended questions without restriction to the above criteria only.

Figure 9-1: Case studies' narrative



It is essential for this study credibility the facts that: a) the three case studies are reputable UK D&B main contractors, b) all informants are experienced top, middle and project level managers (decision makers with an extensive knowledge in the research area), c) key quality and environmental records, reports and systems' documents are made available for the researcher to study, d) access permissions for case studies' D&B projects sites are provided. Also, the triangulation between the coded managers' opinions is vital for judging credibility (Gomm, 2008: 242). The rest of this chapter will report on case studies' backgrounds, major aspects of TQEM implementation, and managers' thoughts over the primary corporate-level TQEM validity. The next chapter, however, through cross case examination, will investigate the theoretical advocated advantages of the project-level TQEM. Project-level TQEM and its impacts and links to the construction cycle will be investigated.

9.3 Case study A

9.3.1 Company Background

The first case company is located in Nottingham. It is a medium-size family business with 30 years' experience in the sector of infrastructure and railway. It has experience in being contracted by a client to manage design and build using it in-house equipment and personnel to meet its client need. The first impression of the company, from the visit, was that it was well-maintained with clear signs for visitors and an overall pleasant atmosphere. The company has 100 employees, some of which are full-time and the rest are hourly-paid employees. Interviewees 'C' and 'Q' are responsible for quality-environmental-safety assurance plans. With such a small number engaged in quality and environmental functions, the quality inspection work has been empowered to the construction and inspection operators.

Since 2002, the company has maintained BS EN ISO 14000 and the quality assurance system BS EN ISO 9000. "*Even though the company's assurance policies were formed in 2002, the company has gained the national rail acceptance for its assurance case and investing in people*" ('C'). This demonstrates the maturity level that has been achieved in terms of quality and environmental management. The company quality, environmental and safety plans form a range of initiatives that aims to ensure providing adequate resources, responsibilities, and time frames for achievement. The implementations of these plans demonstrate the company commitment to the railway group safety requirements.

9.3.2 Major aspects of TQEM implementation

The board of directors of the company is involved in making policies, creating visions, and planning for quality, environment, and safety. The core management committee consists of the 'C' and system manager (vice exhibitive coded as 'Q' since he is considered to be the QA specialist) and the production and sales managers. Their main responsibility is to make policies for running the business smoothly, wining more contracts and to ensure continuous improvement. There is certainly commitment by management to improving the company quality and environment performance on the corporate and project levels. Hence, with no environmental manager role in this company, the 'Q' considers improving the company environmental performance is part of his responsibilities.

From company-related documents, the company's environmental and quality commitment appear to have overall objectives for health and safety, quality and environment, as detailed below. The achievement of these objectives is monitored through an auditing process. "*A formal review is undertaken at the annual management review meeting*" ('Q'). In comparison, more concern is giving to the quality objectives for each project which are defined within the scope of the project plan from the preconstruction stage. Project quality objectives are reviewed and updated as appropriate as an integral part of contract review activities, the details of which are held on the company database.

The company is committed to the prevention of pollution in undertaking all of its construction activities. "*The company's environmental objectives are mainly related to waste, energy, recycling, and vehicle management*" ('C'). This comes in line with the company environmental policy which also ensures compliance with applicable legal requirements. These objectives are based on the likely risk of the environmental impact occurring against the financial implications.

The 'Q' is the representative of the QM committee. He has access to a budget appropriate to solving the quality and environmental problems. "*A specialist M&E consultant assists the project teams with their workplace assessments; responsible for* *the training programme for project managers*" ('P'). The environmental audit includes the workplace evaluations, safety precautions, sufficient knowledge, near-accidents reported, adequate instructions and training, and manuals for machinery. Two persons here, 'C' and 'Q', plan, manage, and coordinate the quality, environmental, safety and health programmes.

9.3.3 Implementation framework at the company

The structure for conducting continuous improvement is by way of having an improvement facilitator who reviews quality, environmental and safety problems together with related teams to find improvement opportunities. "*The company is aware of the importance of quality, environmental and sustainability issues to its business"* ('C'). The interviews and the document analysis demonstrate that the main reason for the clear quality, environment, and sustainability awareness is competition. The government appears to be their major client who tends to deal with the top three contractors out of the five existing competitors specialist in this sector. Some of the examples, cited by the 'Q', are improving energy efficiency on site and in their offices, recycling some of the building materials, and insuring good environmental, health and safety conditions in workplace layout.

"*The company is also in the process of developing a new computerized project management system*" ('Q'). This is a comprehensive system for planning and communications. Within this system QS 9001 and ISO 14001 systems play a major role for:

- Complying, as a minimum, with all relevant environmental legislation and regulations.
- Preventing pollution through reduction of waste and emissions.
- Advising clients and their teams of environmentally positive construction solutions.
- Encouraging supply chain to use sound environmental practices.
- Ensuring the efficient use of resources by the use of recycled and reused materials and by the conservation of energy.

- Protecting important wildlife habitats and archaeological sites that maybe affected by their construction operations as defined in the Planning Permissions.

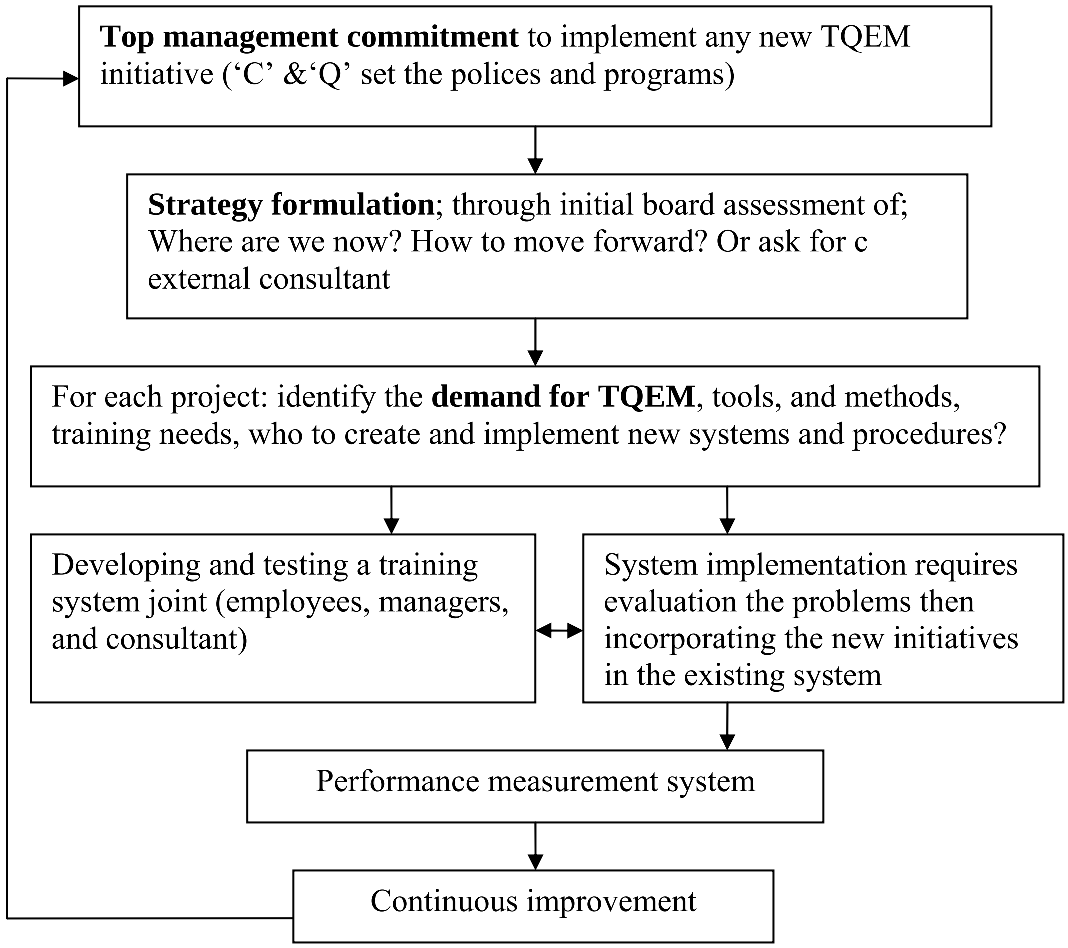
- Ensuring continual environmental improvement by regularly setting and achieving environmental objectives and targets.

- Continuously aiming to increase energy efficiency and reduce our energy consumption

- Ensuring that all employees are aware of this policy and of the environmental effects of our operations through training and briefings.

According to 'C', "*Performance improvement is not only construction-related, but also non-production areas such as purchasing, marketing and human resource management should be considered*". Other indicators such as Employees' opinions, for example, are considered through internal feedbacks. "*The main performance measure, beside profit, is clients' feedbacks*" ('Q'). This aim is to improving job satisfaction, employees' loyalty, innovation, and business culture. Thus, "*staff turn over is relatively high. This might be due to the hourly paid contracts and competitors offering higher salaries to the company experienced employees*" ('P'). Based on the comments raised through the interviews and the relevant documents analysis, Figure 9-2 establishes how the company may implement TQEM framework based on its existing practices. This analysis represents the way for adapting (not adopting) the TQEM primary framework phased approach starting from management commitment to formulating a strategy, implementing the relevant systems, performance measurements and continuous improvement.

Figure 9-2: Case study A analysis



"*The company has not devised a formal framework for implementing quality management, environmental management, or TQEM, although quality and environment had been part of the company philosophy from the outset*" ('Q'). The company's clear vision is framed following from ISO 9000 quality systems and ISO 14000 requirements. In addition, the company has progressively implemented a few quality and environmental initiatives and tools such as a continuous improvement system, statistical tools, quality, a safety and environmental check list, advanced quality planning, and a quality assurance system. There is a positive feedback from the managers interviewed on implementing TQEM in a phased approach.

9.4 Results from case study B

9.4.1 Company background

The second case company was established in 1852, located in Nottingham, as a subsidiary of a larger construction group. It is a family-owned organisation with more than 500 people, and over 150 years of industry experience. The company operates in all construction engineering sectors. It acts as a main contractor with an extensive experience in D&B contracts. It has many offices all over the UK and Ireland but has centralized its quality, environmental and sustainability departments in Birmingham. This centralized department gives consultancy on construction sustainability, renewable energy, life cycle costs, and project team integration issues. The interviews were conducted with the company head of sustainable development department 'S', one of the company project managers 'P', and two representatives (the whole life cycle champion 'E', and innovation champion 'I') from the BRE the company strategic partner.

The company quality design champion and sustainability champion work with clients to establish quality and sustainability standards against which design progress can be monitored and appraised. The centralization of quality and sustainability staff shows that much of the quality and environmental inspection work is already left to the 'P'. 'P' here had a QA training to qualify him for 'Q' role on the project-level. *"M&E role is not influential as they do not conduct regular operatives on site*" ('P'). The company has embarked on various quality initiatives including ISO 9001 certification. The company environmental management systems comply with ISO14001.

The company 'S' stated that "*the company sustainable strategy and direction is managed by the construction board comprising of the chief executive officer (chair) and the local construction office managing directors*". These board meetings are published in an annual reports. "*The company has six local construction offices with each managing director, holding the responsibility for the local delivery of social, environmental and economic aspects*" ('S'). This setting allows developing strong relationships with leading environmental agencies for sharing experience and investing in research and development and social responsible care. "*We have developed a partnership with the UK's leading sustainable development charity, Forum for the Future, and have undertaken workshops facilitated by them to identify the specific sustainable development issues facing the business*" ('S'). The company sustainability department is responsible for developing the sustainable development plan and monitoring progress. The actions identified within the plan are then developed by engaging either our specialist consultancy Re-Thinking or through the strategic teams. This sitting shows the company commitment to providing services and activities on a sustainable basis that respect the environment and people.

9.4.2 Major aspects of TQEM implementation

The company recognizes that its operations have a direct impact on the natural and human environment. Therefore, the environmental concerns are addressed separate from the quality ones and are referred to in the company's key performance indicators (KPI). The company claims to consider any environmental implications of all its activities. Its EM aims are to minimize adverse impacts as far as practicable and to undertake all operations on a more sustainable basis and promoting beneficial effects of its activities. The accredited Environmental Management System is ISO 14001.

This contractor has some pro-active activities toward the environment. Within the sustainability department there is a renewable champion who offers input and advice on achieving renewable energy targets in accordance with their growing importance for public spend. The role of the Whole Life Value (WLV) champion 'E' is "*to make accessible a wide array of WLV specialists and a distinct approach to this area, which links directly with the tasks of the environment, sustainability and renewable*". The sustainability department, also, has a champion for innovation 'I' who provides a direct link to the BRE's innovation unit. "*Working with the BRE our strategic partner, the company has achieved improvements to the process layout through work-study methods to achieve a lean construction environment*" ('I'). Hence, TQEM towards sustainability requires various quality and environmental systems which the company have already established for examples EM, QA, a training system, and an information and data collection system (i.e computerized system to deal with the company centralized structure).

The role of TQEM management-based approach should be the development of business plan and decision making criteria that comprise quality, environmental, and sustainability aspects. "*We are planning to have fully trained in-house BREEAM advisors who work extensively across our business on sustainability initiatives and targets*" ('S'). Together, these initiatives could support implementing TQEM and could inspire many sustainable building solutions. One of the company's 'P' outlined the importance of continuous improvement strategies, people (human resource development), and customer requirements aspects. Yet he pointed out that "*the* *challenge is in developing TQEM culture*". Despite the well-established sustainability and environmental strategies, there are few incidents for negative outcomes due to the common practices (time, and cost focus).

The way in which the company identified customer needs was through a detailed customer satisfaction index, measuring areas such as quality performance, logistics, and delivery. "*The key to TQEM excellence is through a cultural transformation process*" ('S'). Monitoring environmental and quality management aspects, traditionally, has been left to few site inspections instead of building a TQEM culture that empower staff to participate and share responsibility. The main elements that have effected this cultural change were through an organisational re-structure programme, an open communication system (mostly through team briefing) and also a training and skills development package. Following are a few points of the company's performance indicators that are seen to be directly relevant to integrating TQEM:

Objective number 1: Implement the following Constructing Excellence environmental Key Performance Indicators on all new projects. This objective could be translated to the following TQEM targets:

- KPI 1 – Impact on the Environment – Construction process. For example, for housing projects, a target of 7 out of 10 could be set based on the Code of Sustainable home.
- KPI 2 – Energy Use – Construction process. For example a target of 1,100 kg CO_2/£100k could be set depending on the Part L instructions
- KPI 3 – Mains water Use - Construction process. Target 10.5m^3/£100k, for example
- KPI 4 – Waste – Construction process. Target 80m^3/£100k
- KPI 5 – Commercial Vehicle Movement
- KPI 6 – Impact on Biodiversity. Target of 7 out of 10.

Objective number 2: Implement the following Constructing Excellence eKPI's on all current and new projects:

- KPI 1 – Energy Use (Designed) – This eKPI measures the amount of CO_2 emissions caused by the energy use designed into the completed product/ facility and is measured in kg CO_2/100 m^2. This is a one-off assessment which requires the design estimate for energy use per year for electricity (kWh), gas (kWh), and other energy sources, together with the gross floor area to be collected.

- KPI 2 – Mains Water Use (Designed) – This eKPI measures the amount of mains water use that the new product/ facility have been designed to use and is measured in m3/100 m^2. This is a one-off assessment and requires the design estimate for mains water use per year in m^3 and gross floor area to be collected.

Objective number 3: Implement the following new eKPI's:

- KPI 1 – Waste to Landfill – to be implemented on all new projects. This KPI will measure the amount of waste going to landfill as opposed to be being recycled or reprocessed. This will require sites to monitor the destination of waste leaving site.

- KPI 2 – Business Vehicle Mileage. This eKPI formalises the current measurement of CO2 produced during business vehicle miles. This data is collated by external consultancy and is reported annually.

These criteria are seen as very useful for developing TQEM-KPI in a sustainable context, i.e. sustainable balanced scorecard. The company could establish a TQEM framework based on its advanced EM systems. Hence, the 'S' addressed some of the limitations: "*There is a need for more training and skills development system to support the quality and environmental targets and measures*". One particular example given by the 'P' was when it started conducting QS 9000 audits. "*It was found that many of QM and EM targets are not carried out because of the top and middle level managers' limited availability*" ('P'). Therefore, the TQEM framework should start from gaining management commitments. To overcome the highlighted skill shortage problem, upgrading the team leaders' skills, and enabling team leaders to conduct internal audits was suggested by the 'P'. "*The company has just started team leaders' training supported by the local Training and Enterprise Council (TEC)*" ('S'). The company has a variety of quality and environmental initiatives in place, but by the time of this investigation, the company appears to be far away from achieving the targets set out above.

9.4.3 Implementation framework at the company

Informants 'S' and 'P' indicated that the company has separated quality, environmental and sustainability action plans. Hence, one department, the sustainable development department, is responsible for establishing all these plans. The researcher was given access to many related documents which detailed the policies, objectives and approaches towards continuous improvement, customer focus, and the human resource aspects of the organisation.

The company does not have a formal implementation framework for TQEM. Hence, there are two available characteristics for this company that may facilitate TQEM implementation: "*(1) management commitment, and (2) the experience with many quality and environmental initiatives across the whole construction supply chain consideration*" ('S'). The adoption of ISO 9000, for example, means that projects should meet customer expectations, and also allows continuous improvement to be carried out. "*Continuous improvement has lead to the move beyond QS ISO 9000, to the development of self-assessment initiative and to the improvement of KPI*" ('P').

The 'S' pointed out that "*there is a demand for TQEM in the whole construction supply chain in general and in the design stage in particular*". To achieve that, staff involvement is seen essential for developing TQEM culture. The TQEM related phases implemented in the company, according to the relevant documents provided, are summarized in Table 9-2.

Table 9-2: Case study B analysis

Phase	**Main activities**
Awareness	Presentations to employee about the importance of TQEM
Assessment	Investigating the current system deficiencies against TQEM requirements
Strategy formulation & action plan	Draw up a matrix of responsibilities
Review	Review meeting to measure the performance and implement new procedures
Continuous development	Top management review meeting
TQEM certification	Third party audit and approval

"*Linking quality management, environmental management and sustainability programmes had not, to date, been carried out but was thought to be effective step* *ahead for maximizing competitive advantages, minimizing the management system boundaries and recognition*" ('S'). The overall approach to implementing TQEM was seen as an expansion from the company successful experience with ISO 9000 and ISO 14001 by interviewee ('P'). Although TQEM could benefit from this system approach, a framework is required for corporate-level (business and culture) and project-level (performance and procurement) integration across the construction cycle. Through this approach, the responsibility for TQEM could be transferred from the quality department to everyone in the company.

9.5 Results from case study C

9.5.1 Company background

The third company is a major UK construction company with branches all over the UK and Ireland. This general construction company operates over all construction sectors from civil engineering, infrastructure to the housing sector. It is a major engineering and construction group with a reputation for technical excellence established over 140 years in the construction market. The company major clients currently are the NHS and Sainsbury. The first impressions of the project's site were quite displeasing, there was no evidence of a visitor's car park, the temporary project management office was poorly signed, and the receptionist did not seem to know the company 'Q' in the midlands whom the researcher was to meet first. The company 'Q' and two experienced 'P' were interviewed. Some of the interviews were held on one of the company novated D&B project work site.

The company is one of the UK's construction leading companies in highway construction and maintenance. Interestingly, waste management appears to be the company fastest growing concern. "*The Government's multi-billion pound programme to cut landfill means that there is huge demand for civil engineering and investment expertise. The company aims for a head start in this emerging market*" ('Q'). Quality was no longer the responsibility of the quality department but of the people actually involved in production. The structure of the quality management is similar to case study B.

The company has maintained an environmental management system that complies with BS EN ISO 14000 since 1999 in all its construction, contracting, and project management activities. The company has operated a quality management system that complies with the ISO 9000 since 1995. This big company offers comprehensive capability and experience in many related TQEM aspects. It is the responsibility of the company's management to ensure that the management-based systems are effective, complain with current and future legislation.

9.5.2 Major aspects of TQEM implementation

A quality committee is set to plan for environmental and quality issues. In this committee there are representatives from team leaders, project managers, and quality inspectors. The environmental and quality plans are set by the quality committee which consists of top and middle level managers from all departments including design, construction, quality, and finance. The committee's main responsibilities are designing systems, making decisions on quality matters, and reviewing current systems. The company has a continuous improvement plan following from the ISO 9000 manual. In addition to its QS 9000 and ISO 14001 systems, the company has developed a training system and an information and data collection system. Yet, "*the company relies on basic customers' feedback forms as the main performance measure*" ('Q'). The implementation of the various quality initiatives has resulted in shifting the company focus from a rigid structure without process ownership to an organisational structure which is primarily people-focused.

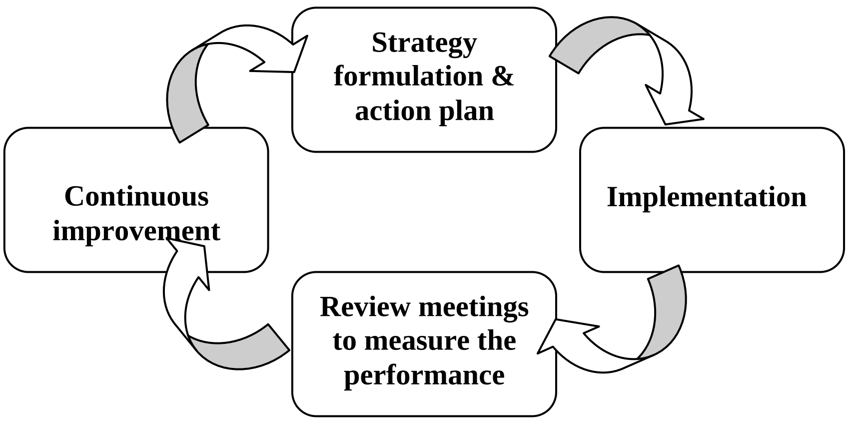
The midland Q manager indicated that "*it will take the company another three or more years to experience any benefits from implementing TQEM*". He also pointed out that customer expectations (TQEM-related) appear to be demanding in commercial and infrastructure projects. For the residential sector, clients need the building on time and within budget, and any environmental or quality defects lead to acceptable individual occupant's inconvenience and low maintenance cost.

The 'Q' confirmed that the D&B procurement has led to many quality defects, as in many cases the construction works start before the design is finished, based on a staged building control approval. "*The wrong procurement practice is driven by the construction culture being time and cost focus*" ('Q'). The new environmental regulations and taxation is driving the change. "*Since 2006, the compliance* *responsibilities are divided among the bid manager (Bid/Tender Stage), project manager (on winning work), office/facilities manager (regular review), and advisor (to provide advice when required at all stages)"* ('Q'). This change aims to identify and evaluate significant environmental aspects at all stages of a project. No environmental KPI were found for evaluating environmental aspects for tendering, design, or documentation.

9.5.3 Implementation framework at the company

When asked about whether the company had any kind of action plan or strategy relevant to TQEM implementation, the 'Q' answers was negative. However, the company does have a management business plan that includes some quality and environmental management aspects. As can be seen in figure 9-3, strategy formulation, implementation, review, and continuous improvement are the key features for the company current implementation practices for all the actions involved in the processes of building sustainability related issues. This approach is similar to Deming P-D-C-A cycle, discussed in Chapter 5. Subsequently, in the strategy a plan part of the cycle, the following features should to be considered: understand the gap between TQEM criteria and the actual situation in the project, set priorities for closing gaps, and develop an action plan to close the gaps.

Figure 9-3: case study C analysis



As with the previous two case studies, there was little evidence of a formal implementation framework being used to progress the TQEM initiative. The basis, on which TQM and EM were implemented, was through a progression of quality and environmental initiatives such as ISOs , team meetings for performance improvement, and people empowerment. The company appears to suffer from the skill shortage, as much of the company's construction activities rely on a semi-skilled workforce, with increasingly less-able supervision affecting the company quality and environmental performance. Also, this often manifests in slow delivery, significant rework to rectify defects, and associated materials waste that is built into the tendering and project costs.

9.6 Validation of the proposed framework

This section summarises the findings of the case studies to the attainment of the theoretical advocated advantages of TQEM framework (Figure 8-1). The theoretical advantages have been established and compared with actual results of the case studies operating a separate certified quality and environmental management systems. The following discussion is centred on the perceptions, comments, criticisms, and suggestions made by the respondents in the case companies.

9.6.1 Case company A

The first observation of the framework is overall acceptability. The company 'C' agreed that it was in general a fair, sensible approach towards building TQEM into a company. The approach is feasible; it had ease of implementation in mind, together with being a simple and practical methodology. It also indicated that it was comprehensive and uncomplicated even to a company that was still new to TQEM.

In spite of these commendations, some constructive suggestions were made to enhance the framework, by 'C'. The first was to include a training system in the framework phase three: management system implementation after strategy formulation and insuring compliance since it was required before any training could be carried out. Training is actually included the same stage within the support systems for implementation.

The second suggestion was "*to include 'evaluate' as a step in phase three: management systems implementation, since financial evaluation, (e.g. cost-benefit analysis), tangible and intangible benefits, improvement to work culture and work environment could also be assessed*" ('C'). The 'Q' believes that "*it is difficult to evaluate and quantify intangible benefits of the framework*". He expressed the need to sometimes have "*good feelings*" regarding the success of an initiative in transforming the organisation. For example, ISO 9000 certification had resulted in increasing the number of enquiries from non-construction businesses such as using recyclable materials, which hopefully would increase sales in the future. Finally, his overall perception of the framework was that it was a sensible approach and covered all the major aspects of TQEM implementation.

9.6.2 Case company B

The main criticism made by the 'S' about the framework was regarding the required resources: "*there were no time elements included, nor other necessary resources*". The 'S' stated that "*construction business in reality is cost and time focus beside the difficulty of implementing TQEM in construction compared to the manufacturing which has assembly line. Construction companies were constrained by limited resources, especially human and financial, and should be considered during implementation*". Since this framework does not intend to address an actual implementation plan, the question will require a separate study. However, the researcher is fully aware that resources are crucial in construction companies and thus we suggest that a framework for construction companies must be at least simple in structure and easy to implement.

Another aspect highlighted by one of this company's 'P' was in regard to TQEM being a cultural transformation. He confirmed that "*management had a key role to play in getting the best out of people through coaching and coaxing during this transformation process*". He agreed that "*the process comprised a series of activities or initiatives which could be implemented, according to resource availability*".

On the positive side, the 'S' recommended the simplicity built into the framework. The general methodology was acceptable and he pointed out that the "*implementation*" stage would be easier with the cellular set-up within his company. It appears that that construction companies do not have to do "*all at once*" ('S') but could progress from one initiative to another. There is a need to include re-structuring as an initiative and it is believed that it can be one of the first to be undertaken when implementing TQEM, particularly in the cultural transformation process.

9.6.3 Case company C

The first point raised by the 'Q' was regarding the amount of time and money that would be required to implement the proposed initiatives within the framework.

Although time and money are important features of TQEM implementation, it was not considered in this piece of research, which was concerned with the practicality and simplicity of capturing the necessary ingredients and a simplified approach towards building a TQEM organisation. Having been certified to QS 9000 and EN 14001, the company has experienced that type of commitment which could benefit TQEM demands an unswerving effort to reach the ultimate goal of being TQEM organisation.

There were two recommendations made with regard to the quality and environmental initiatives suggested by the framework. The 'Q' suggested that "*a training system be included*", similar to company A's recommendation, and also 'supplier development'. He also suggested "*including some form of 'targets' when conducting the review step in TQEM system implementation stage*". The 'Q' confirmed that "*the overall structure of the quality improvement approach provided in the framework was acceptable for small companies*".

The 'Q' opinion with respect to the proposed conceptual implementation framework was very positive in the sense that it presented a simple approach for incorporating TQEM into the company. The 'Q' recommended that "*the management commitment phase is a vital start as top management and the steering body role is the key start".* In particular, management commitment phase is vital for developing policies, vision, and mission for TQEM should form an integral part of the business plan of an organisation. The 'Q' agreed that "*management must not only give its full commitment to providing sufficient financial resources, but also human and other relevant resources such as construction knowledge, technology, and material*". Hence, a suggestion was made by the 'Q' to change phase three of the framework to phase two in order to indicate the level of importance placed on the management system implementation. This was felt to be a good suggestion and will be considered for inclusion in the final modified framework.

With regard to the sustainable scorecard, there were no negative comments. The 'P' agreed to the steps suggested and its effectiveness in measuring the company performance. The researcher was happy for the 'Q' to present it in the management board meeting for possible adoption. No suggestion was made to add any other tools or techniques. Overall, he seemed satisfied with the simplicity that was built into the framework.

In summary, case studies results indicate that the primary TQEM framework (Figure 8-1) is a sufficiently general formal management tool for implementation purposes. It can be stated that most of the TQEM theoretical advantages do exist in construction-related operational environment. The three case studies have endured the pains of quality and environment systems' certification in the hope that certain benefits can be obtained. This section has investigated the theoretical validity of the proposed TQEM framework. None of the case studies has approached TQEM using any kind of framework. Hence, they showed some interest in implementing TQEM framework and provided some constructive feedback as the benefit of the real implementation of the final framework will require 3–5 years for the company to start experiencing some benefits (which does not fit this research timeframe). It was agreed by the informants that the TQEM framework will assist the contribution made by the principle D&B contractor to mitigate and manage the environmental effects of the construction project.

9.7 Summary

The second level of investigation, in the form of three case studies, has been presented in this chapter. This chapter has described the companies' backgrounds, aspects of TQEM implementation, the visibility of the proposed TQEM framework (Figure 8-1).

Overall, the case studies show some similarities in the quality and environmental related approaches adopted by the case companies. This can be looked at from four main areas: (1) people focus as the vehicle for cultural transformation, (2) QS 9001 and EN 14001 are the key systems implemented for achieving quality and environmental improvement, (3) continuous and progressive implementation of initiatives based upon resource availability, and (4) performance measurement system based on a simple feed on client satisfaction.

Apart from these immediate conclusions, the case studies demonstrate TQEM potential implications. Unlike the separated quality and environmental management techniques currently in use by the case studies, TQEM is seen as a step change by all of those involved. This is because TQEM framework is developed to identify sources of knowledge and tools to meet performance based regulations, while considering current availability of materials and labour skill. It is also difficult for contractors to manage all their separate quality an environmental systems' documentation, as a result of the extremely onerous and bureaucratic documentation requirements. With the increasing the environmental regulation on contractors, if EM and TQM systems are not maintained effectively, contractors may find themselves being channelled into managing the documentation aspects of the certification process, rather than achieving the objectives of the improving quality and environmental performance.

This primary framework relevance is based on the analysis which offers a deep insight into the case studies which are motivated and have the capacity to implement TQEM framework. The interviewees expressed an interest in the TQEM management approach for improving their performance, image, clients' satisfaction and competitiveness. The TQEM framework usefulness is based on offering a generic process for improving contractors' quality and environmental performance. Hence, the framework needs to be linked with the construction cycle and detailed guidelines should be given, following from the case studies' informants comments. The framework then will have potential organisational and project benefits on timing, design nature, contractor intervention, recognition, and contractual relationship.

For effective TQEM it is necessary to compose a framework which encapsulates the environmental ethos, policies and objectives of the principal contractor's corporate and project functions. Hence, slice-by-slice TQEM implementation appears to be acceptable by the three case studies, supporting the framework phased approach. The implementation of TQEM was conducted through a series of separate quality and environmental initiatives and business improvements geared towards better ways of managing construction. A common ground for the three companies is about focusing on people for building a TQEM culture. Further cross-case examination and analysis of the impact of TQEM on project design, performance, procurement and management are included in the following chapter to link the TQEM primary framework with the procurement and construction cycle.

CHAPTER TEN

CROSS-CASE EXAMINATION AND ANALYSIS

CHAPTER TEN: CROSS-CASE EXAMINATION AND ANALYSIS

10.1 Introduction

This section summarises the findings of the case studies to the attainment of the theoretical advocated advantages of project-level TQEM. The theoretical advantages have been established and correlated with actual results of the case studies operating a separate certified quality and environmental management systems. The 5 areas for exploration within the case studies are:

1. The measures and results gained, together with the range of TQEM improvement initiatives embarked upon by the company, provided a good indicator of 'how TQEM' the company is. The analysis is primarily conducted through cross-case examination between the companies to look for differences and similarities, thus ensuring that important lessons are learned.

2. TQEM impact on design and decision making in novated D&B projects.

3. The impact of TQEM on bidding documents in novated D&B projects.

4. Whether compliance with building environment regulations had led to an increase in the factoring-in of risk margins anywhere in the design and construction process.

5. Control measures to reduce risk of non-compliance with the new performance-based environmental regulations.

The environmental drivers, discussed in Chapter Two, are already having a profound effect on the managerial and procurement arrangements of UK construction projects. A number of interesting conclusions resulting from the case studies are presented in this chapter. These include the impact of TQEM on tendering practice and documentation, procurement practice, post-tender and collaborative working.

10.2 Initiatives implemented

This section compares the quality and environmental initiatives implemented among the case studies which were reviewed in the previous chapter. This includes; the technical or hard aspects of TQEM (various quality tools and techniques), and the soft/motivational (HR and cultural issues). The various quality initiatives and 'technical quality aspects' implemented by the case studies are summarized in Table 10-1.

"*There are several quality insurance procedures in place to minimize problems occurring at the end of the project due to design defects or workmanship. We are aware that any risks with detailing needs to be managed at bid stage*" ('Q' from case study A). Table 10-1 portrays a wide range of initiatives which have been implemented by the case studies. Some initiatives are newly implemented, while others have been applied for years. This indicates the diverse experiences that each company posses. From the table, it can be observed that companies B and C are more advanced in their application of advanced quality planning tools, KPI and a QA system, compared to company A. Company B, in particular, has implemented almost all the initiatives listed. Self-assessment has only been performed by companies B and C. Self-assessment is an important tool towards sustainable construction. Therefore, according to TQEM strategic levels illustrated in Figure 8-3, companies C and B can be considered to be at level 3 TQEM towards sustainability while company A is still at level 2, Table 10-2.

Unlike the separated quality and environmental management techniques currently in use by the case studies, TQEM is seen as a step change by all of those involved. This is because TQEM framework is developed to identify sources of knowledge and tools to meet performance based regulations, while considering current availability of materials and labour skill. It is also difficult for contractors to manage all their separate quality an environmental systems' documentation, as a result of the extremely onerous and bureaucratic documentation requirements. With the increasing the environmental regulation on contractors, if EM and TQM systems are not maintained effectively, contractors may find themselves being channelled into managing the documentation aspects of the certification process, rather than achieving the objectives of the improving quality and environmental performance

Table 10-1: Results from the case studies

Activity	A	Years.	B	Years	C	Year
Advanced Quality Planning	Yes	5	Yes	10	Yes	15
Advanced Environmental Planning	Yes	3	Yes	5	Yes	8
Advanced Sustainability Planning	Yes	>2	Yes	<5	Yes	>5
Customer Needs	Yes		Yes		Yes	
Customer satisfaction measures	Yes (Feedback)		Yes		Yes	
Supplier development & partnership program	Yes (i.e. now working on developing recyclable materials)		Not indicated		Not indicated	
Quality Systems	ISO 9001	5	ISO & QS	10	ISO &	15
Environmental Systems	ISO 14001	3	ISO & EMAS	5	ISO	8
Statistical Process Control	No	-	No	-	No	
Quality Cost System	No	-	No	-	Yes	<5
Systematic Training System	No	-	Yes	8-7	Yes	10
Self Assessment	Not formal		Yes	5	Yes	8
Benchmarking	Not indicated		Not indicated		Yes	10
Measurement System	Not Formal		Yes (KPI)	5	Yes	8

10.3 TQEM Implications for Management

Before one states whether the theoretical advocated advantages are obtainable in practice, one should investigate managers' opinions of gaining quality and environmental systems certification. It can be looked at from four main areas, namely: a) 'People-focus' as the vehicle for cultural transformation, b) QS 9001 and EN 14001 as the major systems for achieving quality and environmental improvement, c) Continuous and progressive implementation of initiatives based upon resource availability, and d) Performance measurement system.

The first piece of common ground among the three case studies was the belief that a cultural transformation is required for TQEM implementation. To achieve this cultural change internally, different methods were used within the case studies. Re-structuring the construction activities into work teams or cells seemed to be common across the three cases. "*The project managers are responsible for implementing and following up quality/environmental/health and safety assurance on project by project bases*" ('Q' from case company A). With this structure in company A, employees have been empowered to conduct their jobs efficiently, thus ensuring a smoother flow of information and speedier actions to be taken. Most importantly, this teamwork approach and dividing responsibilities will facilitate implementing TQEM compared to traditional functional organisation structure. A construction company structure that creates teamwork and fosters continuous improvement efforts will support TQEM implementation. Moreover, creating communication channels, between staff and management, is important for more informed involvement in the implementation process.

The second common point observed is that the three companies are certified to QS 9000 and are certified or in the process of being certified to ISO 14001. This is a much more stringent version of ISOs and the requirement for continuous improvement has made it difficult to attain, unless the company is committed to this aspect. ISO 9000 has been implemented as a key system for achieving quality improvement in the three cases. It is believed that ISOs could form the basis for setting up systems for TQEM to prosper. Therefore, according to TQEM strategic levels illustrated in Figure 8-3, companies C and B can be considered to be at level 3 TQEM towards sustainability while company A is still at level 2, Table 10-2. The level 3 TQEM companies adapt strategic approach, higher standards, more practices with regard to continuous improvement, and quality and environmental systems, tools, and techniques.

The TQEM concept was no where to be found within the three companies. Hence, it was felt appropriate at this point to evaluate the level of TQEM adoption as evidenced by the case studies. The porous here is to show the differences that exist between the cases/. Level 3 TQEM companies are those which have implemented a broad range of quality and environmental initiatives tools with longer experience. When asked to demonstrate specific practices related TQEM, informant 'Q' form company A provided the following examples; the use of railway recyclable materials energy efficiency in all office work, transportation, and on site activities. For companies B and C, more reactive approach is enhanced. These companies have strategic approach, quality and environmental initiatives implemented, and more staff informed involvement on the company's environmental and quality goals (through newsletters, monthly meetings, and open communication)..

.The environmental drivers, discussed in Chapter Two, are already having a profound effect on the managerial and procurement arrangements of UK construction projects. Although insuring that there is effective EM is no different from quality management functions, construction companies appear to be reluctant to go behind the ISO 14001. TQEM framework composes a structure which encapsulates the environmental ethos, policies and objectives of the principal contractor's corporate and project functions. "*It is difficult for contractors to manage all these systems' documentation, as a result of the extremely onerous and bureaucratic documentation requirements*" ('S' case study B). With the increasing the environmental regulation on contractors, if EM and TQM systems are not maintained effectively, contractors may find themselves being channelled into managing the documentation aspects of the certification process, rather than achieving the objectives of the improving quality and environmental performance.

There is a need to promote a quality and environmental culture, through better management based framework both within an organisation and among various stakeholders. "*A TQEM framework may help formalize and lead to a more effective TQM and EM processes*" ('Q' from case study C). Collaborative quality management environment may also eliminate duplicated efforts between quality and environmental systems. A TQEM framework could improve contractors' planning and control at a project level. If the corporate and project-related TQEM records are collated and dispatched to the client, suppliers, subcontractors through the help of management framework, improvement within a project quality and environmental performance could be achieved. This requires selecting elements from TQM and EM, as discussed in the next chapter.

Table 10-2: Case studies' rating

Contractor / Criteria	A	B	C
ISO 9000	Yes	Yes	Yes
ISO 14000	Yes	Yes	Yes
Longest Initiative	5(QA)	10(QA)	10(QA)
Environment & Site Conditions	Good	Good	Fair
Advanced Sustainability Planning	1 Year	4 Years	5 Years
Advanced Quality Planning	5 Years	10 Year	15 Years
Advanced Environmental Planning	3 Year	4-5 Years	8 Years
Company News Letter	No	Yes (Duration unknown)	5 Year
Performance Measurement System	No	Yes	Yes
Rating	**Level 2 TQEM**	**Level 3 TQEM**	**Level 3 TQEM**

TQEM implementation should start from management commitment. TQEM strategy should specify the required goals, policies and programmes and the techniques. Informant 'Q' from case study A called for "*piece by piece approach until the whole thing has been 'consumed' into the organisation*". This is important for dividing the responsibilities and allocating the required resources. TQEM strategy should be built on the company strengths to enable the mission to be accomplished.

10.4 TQEM Impact on Design and Decision Making

As the impact of TQEM is still being recognized there seems to be mixed opinions among the case studies' interviewees on whether the performance-based quality and environmental management led to an over-reliance on specified techniques to speed up the process of gaining projects' approval.

The compliance with the new performance-based environment building regulations, 2006, has increased iterations between the architectural design team and the M&E consultants. The commercial concerns of clients were seen as a major barrier to this compliance. The following are the main related findings out of the three case studies:

- Case study A informants agreed that: Clients need to change their attitude and understand the need to bring in the M&E consultants earlier despite the extra cost.

- From 'Q's perspective: It is still the contractor's perception that EM is driven by regulations while TQM is market driven. Hence, informant 'Q' from case study C stated that "*the difference of constructing sustainable buildings and non sustainable buildings is decreasing*".

- From 'P's perspective: Before the new environmental regulations there was still reluctance from developers to involve consultants at an early stage, as there was the issue of extra fees. The new performance based regulations force this on all the design teams as they have to work together at a very early stage. This was confirmed by 'P' from case study C.

However, it was generally recognized that without the introduction of performance based regulations, design consultants would normally find it a challenge to convince clients to add to project expenses to the fees needed for higher environmental and quality standards. "*A minority of clients required higher building performance in the design phase than required by basic compliance either as a marketing opportunity or in fear that energy requirements are tightening over the duration of which the project is being realized*" 'Q' case study C . Hence, it was generally noted that these clients tended to be either for large scale projects or government funded projects.

Within the design team, implementing TQEM is seen to further erode the architect's status due to the following reasons:

- The role of the architect as the design leader is slightly eroded. 'C' from case study A explained that architects do not have the skill in house to deal with TQEM, specialists have to come on board earlier on in the scheme.

- The building services engineer becomes a more critical partner in the building design. It is all about collaboration. Yet "*There is a lot of iteration and this is time consuming and it is not cheap*" ('Q' case study C).

- "*When the job goes to planning we would make sure that we have frozen the envelope design and specification so we are ensured that the environment and quality is delivered"* ('E' in case study B). Hence, it is dangerous to define what environment and quality is later on in the project where cost becomes a critical factor.

- "*We take it up to planning in terms of the M&E, the rest of the team will be novated to the contractors, but a lot of clients retain the M&E consultants on their side to assure quality*" ('Q' from case study A). Therefore, the contractor will appoint a different M&E consultant to do the detailed design and installation. It was suggested by 'Q' from case study C that *"With TQEM set up, to get you through planning, the performance specification and major design elements are already fixed for the sub-contractors on the performance, so the plant efficiencies are fixed".*

It was generally noted that TQEM's impact on design and decision making within the design teams is seen to further erode the architect's status.

10.5 TQEM Impact on Bidding Documents in D&B Procurement

There was a general assumption amongst interviewees that D&B was the procurement arrangement most likely to be encountered. Novation (by the client to the contractor) of lead designers (i.e. architects) was taken for granted but the prospect was raised of novation of the client's M&E consultant (to the main contractor, or even to a specialist sub-contractor) in order to preserve continuity and responsibility for compliance with the new environmental building regulation, i.e. Part L2006 in the form of the as-built model. Two-stage tender approach is recommended as TQEM could become an integral part of the tendering documents. A preference on this was expressed by some interviewees as follows;

- Two-stage tendering is found to be the best where the contractors are brought on earlier and all the design team is novated. Informant 'Q' from case study A indicated that *"There are advantages as the project would be taken up to planning permission phase, then the contractors get bidding for the project"*. The reason for these advantages was clarified by 'P' from case study B *"As the contractors participate in the rest of the process, the reason this works best is because the client wants to control the cost and the contractors are capable of delivering a project on cost and time*". In other words, Two-stage tendering is found to be the best for better collaboration between designers, consultants and contractors at an early stage to deliver TQEM.

- TQEM should be a major part of the bidding contractual documents. "*Contractors will reject to bid for a project if there was not enough proof to comply with the new performance-based environmental regulations requirements"* ('Q' from case study C).

- "*The consultant specification and tender drawings form the contract and the contractor implements the contract by interpreting the contract. They are not making big decisions or strategies"* ('E' from case study B). If a contractor wants to propose an alternative then they will have to demonstrate compliance with the performance-based environmental regulation.

- It was agreed by the case studies' informants that TQEM integration should be brought on earlier to provide tender stage specifications. "*We insist on a TQEM specifications at tender stage*" ('C' from case study A).

The success of the D&B procurement route could be undermined by issues arising from the rigid professional cultures of individual participants within project workgroups. These have the potential to inhibit the achievement of the TQEM key espoused benefits for better D&B project outcomes, i.e. promoting the integration of the design and construction processes, and improving the principle quality and environmental performance.

10.6 The Risk of Non-compliance

This section discusses the necessary change in risk and measures to reduce the risk of non-compliance with the new environmental building regulations. Compliance with building regulations is an item that now appears on all D&B contractors' risk matrices. Contractors will price for this risk, and in some cases even decline to tender. A preference on this was expressed by some of the case studies' informants;

- "*If quality and environmental specifications are not provided [at tender stage] then we would insist on stating that we have priced the project as per information provided and if we are successful in being appointed, the client will have to fund any changes due to non compliance. We would not take that risk*" ('C'from case study A). For example, "*compliant with Part L (2006) will have to be priced (for example changing the building services systems). We would not take that risk*" ('Q' from company C).

- "*Before we approve novation we seek evidence of compliance with any environmental building regulations". You then do not allow changes to happen to the project once the contract is signed or we put in extra money to manage the risk of non-compliance"* ('C' from case study A). Interviewee 'Q' from case study C indicated that *"the new environmental building regulations in a way force the client to produce large amount of money built up as a risk".* Hence, this will add consequential quality and environmental improvements to specified equipment and materials in the building.

- "*Compliance with all building regulations is on the risk matrix and we put a percentage to this"* ('S' from case study B). The industry does not seem experienced enough to take decisions on change for better environmental performance without TQEM framework. 'E' from case study B stated that "*without a management-based framework, we would not like to take the risk of implications; therefore there is a conservative approach to handling this risk".* This is because *"without running a management-based framework even the* *consultants would not know the answer if the building is compliant or not*" ('Q' from case study C).

- "*I haven't heard of a contractor turning down a bid for fear of non-compliance with the environmental regulation. Everyone accepts it is a genuine risk; who wants to take on a fixed price for a project when a large piece of the design is still at large? The first thing they would want to do is to quantify the risk and deal with it quickly*" (Q from case study A).

Because of the sensitive nature of the environmental calculations required for the as-designed to match as-built, contractors are reluctant to alter certain key elements of the detailed design. For example, there is a strong link between final facade design and detailing and how it contributes to the building energy consumption. The three case studies indicated that they would freeze the design and specifications rather than take on the risk of non-compliance with the as-built framework later on in the project. This defies the normal rationale behind D&B, where flexibility to value engineer changes in specifications and detailing during construction affords contractors important commercial advantages. This statement is supported by the following interviewees' comments;

- "*The design should be freezed in its design once it complies with regulatory requirement but once it is costed*" ('C' from case study A).
- "*We would rather give the client a number of choices of systems that are constructed off site that we have tested and know that they meet the environment regulations*" ('Q' from case study C).
- "*As a construction company the majority of the risk in our business is on our construction projects. We adopt a precautionary approach to risk management with an individual Risk Register for each project"* ('S' from case B). This register should be developed at the start of the project with the key stakeholders to ensure all the issues are understood and appropriately managed.

'S' from case B stated "*Our strategic business risks are considered at bimonthly construction board meetings where overall performance is reviewed and progress against strategic plans including sustainable development are reported*". This is seen essential criteria to consider by Const.TQEM as it enables the company past and current quality and environmental performance and the planning for the coming year to be formally evaluated at annual strategic planning, budget and people asset presentations. Hence, all directors are required to declare any interests outside the business to avoid conflicts.

For TQEM to deliver performance-improvement towards sustainability and manage risk, it is vital to ensure that TQEM is at the heart of the business, embedded into its decision making processes, culture, values, and also turned into real outcomes, with projects that are attractive, efficient and provide excellent value. Const.TQEM framework could made significant changes. Const.TQEM framework could transformer sustainable procurement and management functions from a paper based system to a fully TQEM system. It raises awareness among capital procurement and property contracts teams to specify buildings with increased environmental performance and introduce local suppliers and specialist subcontractors into supply chains.

10.7 Responsibility & Liability

The three case studies show a trend to engage with more experienced and qualified sub-contractors to deliver quality building components and workmanship to meet the performance based targets. In the case of the completed building failing to comply with environment building regulations, contractors would attempt to rectify the problem (particularly if it is concerned with workmanship). If, upon investigation, there was a major design problem attention would turn to designers and specialist subcontractors.

It is interesting that the three case studies professed a reluctance to litigate, or even claim, under such circumstances. In the current procurement environment, where contractors regularly alternate between ‘traditional’ and D&B arrangements, the relationship between designers and contractors is seen as a ‘political’ issue. Contractors would rather absorb problems than sour their relationships with designers (who effectively lead to clients and more project work for contractors). This point is confirmed in discussions with the following interviewees;

- "*If the building does not comply after construction, we need to establish why it failed. In a D&B project we try to put the problem right first then investigate the reason so we can get the completion certificate*" ('Q' from case study C).

- "*It is a political issue to sue designers in case there is a design failure. The contractor would try to protect the designer*" ('P' from case study B). Many environmental tests then must be carried earlier on rather than waiting till the completion date.

- "*We had problems with running environmental assurance calculations as-built, and finding out it failed but we managed it by improving the heating systems so the problem is absorbed*" ('Q', from case study C). Those calculations as built need to be done as soon as the design and services are built not nearer to the completion date.

- "*There are also several quality insurance procedures in place to minimize problems occurring at the end of the project due to design defects or workmanship. We are aware that any risks with detailing needs to be managed at bid stage*" ('Q' from case study A).

Const.TQEM should ensure that contractors operate a management system that is consistent with the requirements of the new building environmental regulations. In this context it is important to pay particular attention to TQEM policy, practices and performance and management system, along with the risks associated with the material and services to be provided. TQEM should include methods for monitoring and assessing contractor performance against TQEM objectives and performance criteria.

10.8 TQEM and client satisfaction

A radical change in industry practice that would improve the quality of the construction process and the levels of customer satisfaction could be driven by evaluating the quality and environmental performance of the contractor. The case studies have supported the interrelationship between quality, client satisfaction, efficiency, productivity and innovation in the context of the construction industry. It should be noted here that the term 'construction client' includes both the owner (i.e.

the agency or organisation funding the project) and the end-user of the construction (e.g. the general public).

Quality and environment practices may be difficult to measure directly. The three case studies agreed on one proxy measure, which is customer satisfaction. Case study B, informant ‘P’, argued that, across most of the current market, aiming for high quality is a questionable commercial strategy which often adds little to shareholder value. Contractors A, B and C emphasised the importance of meeting the regulatory and warranty standards, but in a market that does not offer a cost-effective return for higher quality, there is little incentive for them to go further.

The picture is not wholly uniform, however; some parts of the market do still recognise and pay a premium for quality. Case study A, for example, although it has the lower income compared to the other two case studies, it is motivated by reputation risk. “ *Our business depends on our good name in the market*” (‘Q’ case study A). At the upper end of the market, case studies B and C’s clients, with more disposable income, are more likely to recognise and value long-term quality and environment in design and construction, not least in the inclusion of energy-saving and other environmental features. ‘E’ from case study B indicated that “*there is different quality culture associated with the sector of the project. The demand for affordable houses has resulted in delivering large numbers of poor quality homes”*. In contrast, for commercial and civil engineering project, the public demand high quality unlike the housing sector where quality defects lead to expected individual inconvenience. Likewise, ‘Q’ from case study C indicated that “*if the quality of infrastructures is poor in design or construction, it will rapidly become a cause of fresh economic and social problems, expensive to resolve and with consequences well beyond the building itself”*.

The case studies’ quality and environment-related customer satisfaction issues have focused on the quality of design and the level of conformance to design. Quality and environment of design involves the degree to which features of facility conform to the client’s needs. In traditional procurement, quality of design is the responsibility of the design team. The level of conformance to design indicates the degree to which the constructed facility delivered by the contractor is consistent with drawings and specifications.

10.9 Problems associated with Implementation

This section focuses on the practical problems associated with implementing TQEM based on case studies finings. Chapter seven established the main advantages of implementing separate quality and environmental systems out of the survey results. However, the implementation process can be the most problematic one. The following section establishes the problems and suggests solutions for the TQEM to consider in order to ease the implementation process for construction-related activities.

The previously discussed research on TQM, EM and TQEM in Chapter Four considered horizontal coordination based on the flow of work processes and the linkage with suppliers and customers. Interviewee from case B suggested that TQEM should be a customer satisfaction rather than an internal efficiency focus. Informant 'P' from case C envisaged that "*TQEM-oriented organisation should have processes rather than functions as a basic fundamental unit of analysis*". TQEM is generally perceived to de-emphasize status distinctions while emphasizing employee empowerment. The flow of ideas in the case studies shows several common factors (gathered through observational notes, documents analysis, and interviews) which may cause resistance to TQEM deployment in construction. These factors can be summarised as follows:

- Misconception of cost, environment, and quality. Main contractors may perceive TQEM as an extra cost. This is probably because they do not always realize that "*it is not the environment that costs but rather the non-conformance to environment that is expensive*" ('E' from case study B). The source of costs associated with the non-achievement of quality includes the costs of rework, correcting errors, reaction to customer complain, having deficient project budgets due to poor planning, and missing dead lines. Compared to the manufacturing sector (Chapter Three), cost in construction industry is being compounded by prevention and appraisal costs coupled with non-conformance costs. The cost of TQEM could be divided into the cost of a) cost associated with conformance to requirements and b) costs associated with non-conformance to requirements.

- Organisation stability. The UK construction industry has a high number of organisational collapses, especially during a downturn in the economy. Thus commitment towards TQEM may take several years to provide 'pay offs'. This may be perceived as futile or misdirection of resources. As compared to the head office, the building site is transitory. This was pointed out by the 'Q' (case study A).

- Upper management commitment is vital for TQEM employment. Integrating teams and processes, creating a learning culture is important factors for performance improvement. TQEM could provide a framework for ongoing structural organisational learning process. This point importance was emphasised by 'P' from case study C.

- Employees need to be trained for understanding the process, working in teams, finding the source of the problems, and correcting the causes. "*TQEM improvement teams should be set up to insure environment and quality mentality is instilled in everyone within the organisation*" ('Q' from case study A).

- Suppliers and specialist subcontractors should be integrated into the TQEM process. Suppliers' relation should progress in the direction of supplier partnerships with both parties benefiting from the relationship. Both parties should seek to improve quality and environment towards the intention of forming long-term relationships. The important of this point was discussed with 'C' from case study A, 'Q' from case stud B, and 'Q' from case study C).

A successful implementation process is dependent upon the strong commitment of senior management. This commitment needs to be demonstrated through policies. Issues of authority and overcoming resistance to change are also not mutually exclusive. If the main contractors are to avoid resource problems, senior management must provide adequate funding for the project and sufficient time for people to participate. Staff participation is vital during the implementation phase of TQEM.

10.10 Project-Level TQEM Key Factors

The requirements of restructuring for project-level TQEM implementation purpose should include consideration related to customer focus, continuous improvement, leadership, employee involvement, teamwork, customer-supplier relationship, and process improvement. The cost associated with implementing TQEM could be substantial, depending on the size and the nature of the company. However, Oakland and Marosszeky (2006) indicate that the cost incurred from not achieving quality can be up to 12% of the total project cost. The following are key project-level TQEM factors:

- Facilities, process technology and capacity: Process flexibility can support TQEM activities. An example from case study B is analysis of waste management.

- Capacity: Very little research has explored the influence of the natural environment on decisions about the amount, type and timing of capacity expansion or decommissioning (as discussed in Chapter Four). At first glance, capacity decisions may appear to have little direct linkage to TQEM, yet the implications of changing regulations and raw materials can directly affect capacity. Capacity must be added on two fronts simultaneously, 1) to produce the product and 2) to recycle all or part of the product (a major progress has been achieved on this end by case study A).

- Integration: Reverse logistics and construction supply chain concepts focus on re-engineering the supply chain toward the development of a closed-loop system emphasizing flows of material from consumers back to manufacturers. The concept of reverse logistics reflects an extension of the life-cycle management and the cradle-to-grave environmental philosophies. Interviewee I from case study B indicated that "*innovative firms practice design for the environment and develop reverse distribution channels for the recovery of used materials*".

- Infrastructural decisions: Infrastructural operating decisions are viewed as being much more tactical in nature because of the myriad of on-going decisions they encompass. Informant 'Q' from case C indicated the need to link decision makingcriteria to specific operating aspects of the business and their tendency not to require large capital investments at a single point in time. Infrastructural decisions include those relating to suppliers, new products, workforce, quality, management, and planning and control systems.

- Workforce: the researcher has considered the role of culture in TQEM implementation. This was agreed by all cases' informants. However, little research is found in operations management that has studied the role of operations managers and employees, particularly at the facility level. For TQEM, similar to quality management, the direct involvement of front-line operations personnel may prevent environmental problems from occurring and identify both opportunities and processes for improvement.

Planning and control systems enable both proactive and reactive environmental activities taking place on the project-level. These systems often implicitly include structures and procedures that prevent, limit and monitor environmental impacts. Environmental management standards such as ISO 14000 provide guidance for developing environmentally-friendly organizational systems, although individual operations must adapt corporate policies to site-specific risks. This research opens the door for further research on TQEM organisational impact.

10.11 TQEM and Sustainability

The construction market reaction to higher environmental standards is mixed. The construction industry is central to both climate change adaptation and mitigation. The researcher benchmarks the case studies relevant documents (i.e. environmental policies, sustainable strategies and practices) against the following criteria of (WFE, 2002) for:

- ensuring suppliers extracting and developing natural resources and processing and modifying resources
- designing and building infrastructure
- meeting the needs of clients
- recovering and reusing resources
- producing and distributing energy.

For case study A, as the government is their major client, the company is committed to its advanced Energy Efficiency Policy. This is an example of the construction sector significant role in helping the Government to reach its target of a 20% reduction in carbon emissions by the end of the decade and 60% by the year 2050.

Informant ‘Q’ from case study C stated that “*the difference of constructing sustainable buildings and non sustainable buildings is decreasing*”. Form case study B, informant ‘S’ stated that “*There is ever increasing pressure on the construction sector to integrate environmental management in the main stream of operational management*”. Globalization of the industry and the market place is an issue for case study B, a major building contractor, creating international competition for projects and expertise; internationally. For this reason, more consolidation is taking place across the design, construction and supply chain. This demand stands behind the case studies expressing their demand for integration of TQEM in design and construction processes to improve productivity.

Since it is always down to people to deliver any change, the challenge is integrating TQEM on cultural levels. One reason is “*the increase importance of quality and environmental installation that justify a move into ‘supply and fit’ on a much wider scale than at present*” (‘P’ Case study C).

Based on the case studies outcomes, table 10-3, and demonstrates TQEM key elements toward achieving sustainability. These elements include: a) changes through design, which includes considering the alternatives in design for client, b) changes through performance, c) change of attitude, d) and change of culture.

Table 10-3: TQEM & Sustainability

By design	**By performance**	**Changing Attitude**	**Through Culture**
• Consider the alternatives in design for the client • Planning requirements • Sustainability checklists • Building Control and regulations	• Conservation of fuel and power • CO_2 emissions • Sound Insulation • Building regulations Part E • Building regulations Part M	• Acceptance of responsibility • Responding to change	• Try alternatives • Be prepared to give up accepted practices

This section has noted a movement for change in the construction industry, for radical improvement in the process of construction by developing its quality, environmental and sustainability performance improvement framework.

10.12 Summary

The environmental legislation, taxation, and reputation are already having a profound effect on the contractors and procurement arrangements of UK construction projects. A number of interesting conclusions result from the case studies:

- In terms of TQEM's impact on tendering documents, design and performance, unlike many management approaches for performance improvement, TQEM represents a structural organizational learning for contractors. The interviewees confirmed having already experienced the emergence of a new pre-tender information document when building separate quality and environmental strategies and start by gathering the clients' requirements. Replacing this with one TQEM document will become indispensable, as in its absence, most contractors would decline invitations to bid. If the TQEM strategy fails to demonstrate compliance with the environmental regulations, contractors will consider such non-compliance in the design stage as a particularly unacceptable risk.

- TQEM's impact on procurement practice is vital. Main contractors and design-and-build contractors may have the motive and capacity to implement TQEM. This is because the common practice of 'novating' designers to Design-and-Build contractors is not only compatible with the regulatory developments, but is likely to be extended. The case studies indicate a preference for novation, and increased tendency to novate energy performance assessors, such as M&E consultants, to the relevant specialist subcontractors. This is considered necessary to ensure continuity of responsibility for the TQEM in its 'as-built' form for final compliance with environmental regulation, initiatives, and clients' requirements.

- In terms of post-tender TQEM, contractors operating in a Design-and-Build strategy will 'freeze' designs earlier, and, in order to avoid risks, forgo the potential for later value engineering which they see as significant, as agreed by the interviewees. This approach will prompt an increase in collaborative working between design and construction teams. TQEM for contractors requires much iteration at the design stage and, more than ever before, invites close collaboration between the various professionals involved. If, in line with present procurement trends, projects are commissioned on a Design-and-Build basis, it is imperative that the contractors are fully involved at the design stage if they wish to exercise TQEM: The opportunity to do so after the acceptance of the bid is severely limited by the technical complexities surrounding environmental compliance.

TQEM, for a comprehensive view of construction, suggests dealing with the business (as received by the owner) and processes (as received by the end-user) as well as aspects of the corporate TQEM culture. Such a dissection of construction activity facilitates the development of strategies to define, operationalize, measure, and improve construction quality, environment, and sustainability. Contractors appear to be confronted with many dynamic forces, from competition to litigation. Contractors operating in a much more paradoxical business environment need to be assessed in a contemporary manner that will take into account the innovative characteristics that they are exhibiting as business. The Const.TQEM framework is presented in detail in the next chapter.

CHAPTER ELEVEN

CONST.TQEM FRAMEWORK TOWARDS SUSTAINABILITY

CHAPTER ELEVEN: CONST.TQEM FRAMEWORK TOWARDS SUSTAINABILITY

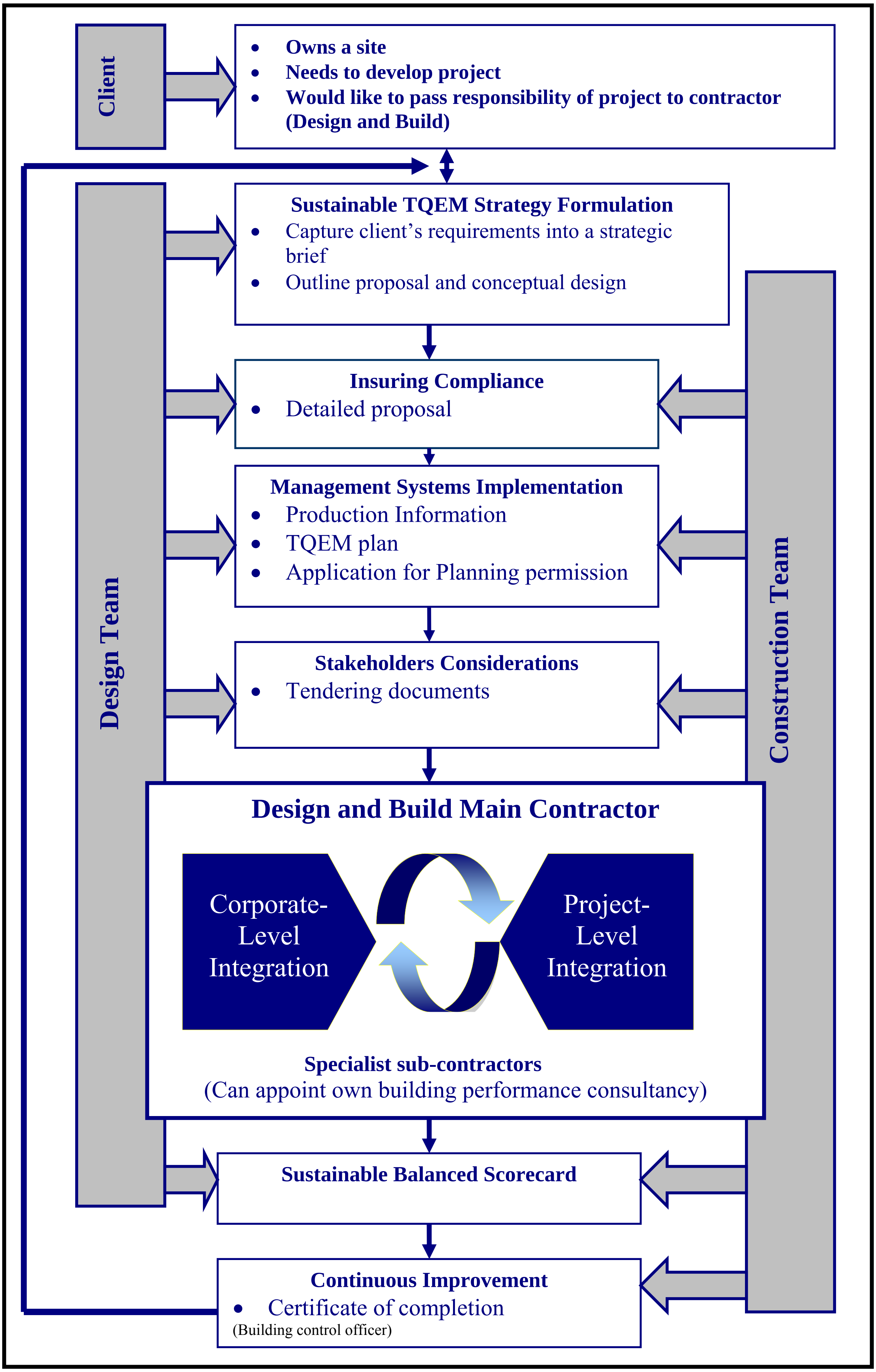
11.1 Introduction

In this chapter a new concept of Const.TQEM and a new framework are presented. Const.TQEM exemplifies the concepts of TQM and EM for the construction sector use. This means that the compliance with the new performance-based environmental building regulation should be extended from the design phase to management, performance, and procurement. The framework considers TQEM attributes for main D&B contractors on the corporate and project levels and the interaction among all the parties involved in a project realisation. This will allow contractors to tackle building features that may affect building performance earlier in the project and to change existing tendering procedures (tendering consortia here needs to develop design specifications rather than detailed design as part of there tender).

Const.TQEM framework for action is developed as a tool which identifies sources of knowledge and mechanisms to meet performance based regulations, while considering current availability of materials and labour skill. It is believed that the adoption of TQEM in construction companies must not be a fully-blown approach but a gradual progression and selection of appropriate tools with the ultimate aim of continuous improvement. Based on TQEM key successful factors on the corporate and project levels, the framework pictures the interaction between all parties involved in a novated D&B project as illustrated in Figure 11-1.

The framework provides a phased approach. This approach's stages are designed around the natural flow of TQEM requirements in each step of the construction supply chain. TQEM implementation guidlines are described. This is intended to be non-prescriptive and the adoption of a TQEM to be dependent upon the demands and priorities established by contractors.

Figure 11-1: TQEM framework



11.2 Const.TQEM

Const.TQEM is a standardized methodology for integrating TQM and strategic EM into a comprehensive lifecycle approach to construction project. Const.TQEM includes a broad range of activities aimed at improving contractors performance (corporate and project levels). It offers general engineering approach to improve the design, operation, and environmental quality of the building.

Const.TQEM new concept and framework relevance is based on this research survey and case studies' analysis which offers a deep insight into novated D&B contractors who are motivated and have the capacity to implement TQEM. Novated D&B procurement strategy is not only compatible with the new performance-based environmental building regulation and innovation but it is likely to be extended in the future. The attributes of Const.TQEM systems is divided into corporate-level and project-level. This is mainly because the concept of TQEM requires organisations to establish a well-structured and explicit system that identifies, documents, co-ordinates and maintains all the key quality and environmental-related activities throughout all relevant contractor's company and site operations.

Corporate-level Const.TQEM refers to a set of core values that promote the delivery of increased value to customers and improvement of overall company performance and capabilities on the corporate-level. The survey revealed corporate-level TQEM key successful factors: (i) customer driven quality, (ii) environmental leadership, (iii) continuous improvement and learning, (iv) employee participation and development, (v) fast response, (vi) design quality and environmental prevention, (vii) long range view of the future, (viii) management by fact, (ix) partnership development, (x) and corporate responsibility and citizenship.

Project-level Const.TQEM requires an in-depth look at both construction performance and procurement system. The case studies undertaken in this study examined the project-level TQEM indicators in the following six areas: (i) briefing by the client, (ii) the design process, (iii) materials and component selection, (iv) project assembly on site (construction performance), (v) project management activities, and (vi) systems to promote project TQEM. The transformation process (i.e. the service) from resources to the constructed facility is referred to as the contracting service. The constructed facility and the contracting service form the construction project. The customer satisfaction experienced with the constructed facility and the contracting service defines project-level quality in construction.

Const.TQEM should be integrated throughout the life of a project. This means that it should address the changing balance of TQEM value and risk once a contractor is appointed. It is very important that contractors ensure that their objectives (TQEM requirements) are included in the contract documentation. Clients must also understand holding, transferring and sharing risk. The level of application of the framework should be determined by the category and character of a project in addition to the procurement route envisaged as discussed in the first chapter. As can be seen in table 11-1, at the integration phase, the framework considers the TQEM at each project stage as follows:

- Concept: Identify clear project objectives regarding quality and environment. Establish whether construction will meet client quality and environmental requirements. If construction is the right answer, proceed.

- Feasibility: Test proposed design options against project objectives, for TQEM values sought and risk faced. The best solution incorporating TQEM improvement ideas is developed in the next stage.

- Scheme design: Test proposed key elements and systems of the design option against project objectives and identifies TQEM values and risks to achieve an agreed design. The selected solutions are carried forward into the next stage to fix its details.

- Detailed design: Test all detailed design options against TQEM values and risk to meet project objectives. This will achieve total design agreement.

- Construction: Manage and monitor TQEM to meet project objective. Evaluate any proposed changes against project objectives.

- Operation and maintenance: Re-assess users' needs and identify any new objectives and associated quality and environmental standards strategies for the whole life cycle of the facility.

Table 11-1: Approach required at each stage of a project

Stage	TQEM requirements	Approach required
Pre-concept	The focus here is the business case and the question 'is construction the right answer?' If the required quality and environmental standards cannot be achieved, it should be abandoned	Through a facilitator with experience in business management/ strategic planning
Concept	Assessing the ability to create a business solution using construction. The identification of the objectives and their ranking Analysis to produce quality and environmental statement	By encouraging creativity, reaching a consensus approach using a facilitator
Feasibility	Creative thinking to ensure options are explored and identifying the best design solution. Managing the evaluation processes. Reviewing the quality and environmental value sought and risks faced statement. Establishing TQEM improvement ideas and measurement.	
Scheme & detail design	As the best design is taken into this stage more time is spent addressing the identified risks and seeking innovative solutions. Ensure quality and environmental standards of the project objectives are maintained and the client is informed of any further opportunities to enhance value through TQEM.	Through a manager with facilitation skills
Construction	Once the project is agreed the process takes a monitoring nature. The way the TQEM will be achieved must continue to be recorded and all the known risks fully defined. Soft management tools help draw out this information but	By system approach with manager

	it needs to be systematically recorded, assessed and monitored by the TQEM manager. If significant changes are required then the initial processes can be repeated to assist decision-making.	
Operation & maintenance	(out of the study focus)	To suit circumstances

The detailed phased integration and guidelines for using the framework are explained next.

11.3 Key Stages within the Framework

These TQEM management procedures are established to ensure that D&B contractors operate a management system that is consistent with the environmental requirements and provisions of the UK government. In this context it is important to pay particular attention to the standards of work and environmental protection expected from the contractor, including agreed TQEM objectives, performance criteria, sharing relevant information, relevant training program, methods for monitoring and assessing performance against agreed TQEM objectives and performance criteria.

In this section more details can be found on breaking down the framework phases (Strategy formulation, Insuring compliance, Management systems implementation, Stakeholders considerations, Integration, Balanced scorecard, Continuous improvement and overall Ongoing audit and changing business culture). It provides a guide for using the framework Figure 11-1.

11.3.1 Phase One: Strategy Formulation

After positioning themselves on the TQEM levels, individual construction companies should start by formulating a sustainable environmental strategy. Integration should start at the strategic level and be aligned with planning and decision-making processes as a foundation for sustainable oriented TQEM. This strategy is built up by the elements discussed in Chapter Five. Thus three steps should be given a high priority in the formulation stage, namely:

Step One: Gaining and maintaining management commitment

Step Two: Developing TQEM Policy

Step Three: Developing TQEM Plan

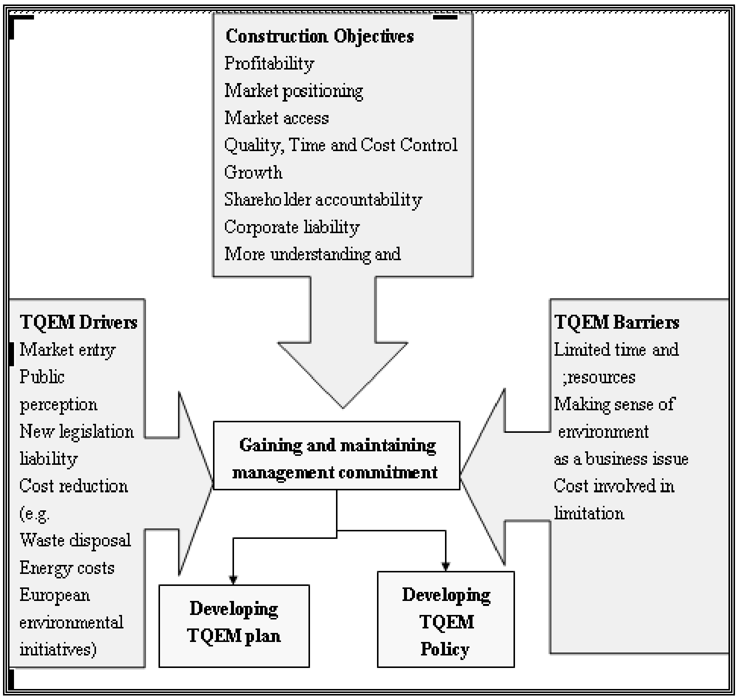
These steps and activities can be seen in Table 11-1 while Figure 11-2 illustrates the phase key elements. Top management commitment should be gained by making sense of the TQEM as a business issue. As soon as a clear commitment statement has been gained, the policy and plan should be developed. These steps involve priorities and identify what should be done for integrating TQEM which comprise of setting the objectives in light of enhancing the drivers and the construction industry characteristics for overcoming the barriers identified in Chapter Eight. Auditing at this stage includes ensuring a clear commitment statement and objectives, required resources' allocation, and a TQEM team with representatives from the organisation key activities, policy and plan drafts.

Table 11-2: Phase One: Strategy Formulation

Phase One: Strategy Formulation		
Steps	**Purpose**	**Activities**
1. Gaining and maintaining management commitment	• Aligning TQEM with strategic and tactical planning • Formulating long-term sustainability mission	• Addressing the five stars strategy requirements (with more understanding and quick respond)
2. Developing TQEM policy	• Addressing sustainability issues • Raising staff TQEM awareness	• Identifying the company TQEM drivers, demand, potential benefits • Allocating resources and responsibilities policy draft
3. Developing TQEM plan	• Setting commitment statement, objectives, plan and policy draft	• General planning for company activities, responsibilities, timeframe and cost

The survey analysis provides the TQEM key factors. The benefits realised from the environmental strategy, i.e. efficiency compliance, liability reduction, cost-saving and revenue-generation can be seen in Figure 11-1. By moving from a compliant strategy to a sustainable strategy, organisations may achieve many competitive advantages. This phase evolves in three steps. After getting management commitment, the TQEM policy and plan should be developed.

Figure 11-1: Phase One: Strategy Formulation Key Elements



11.3.1.1 Step One: Management commitment

The first step, which is probably the most difficult, is gaining top management commitment. It is the key factor for supporting the strategy and providing the resources and other change requirements. Thus all the levels of the organisation should be aware of the TQEM strategy's importance, and should understand and participate in creating new opportunities out of TQEM.

Without the active involvement of the board of directors, it will be difficult for an organisation to implement sustainable business practices. Corporations are encouraged to establish committees responsible for setting corporate policies on TQEM and for dealing with issues such as health and safety, personnel policies, environmental protection and codes of business conduct. Few construction companies, as the research results show, observe variable levels of EM. It can be anticipated that the board also has a role in monitoring the implementation of its policies. At this step senior managers should, they may wish to use external consultancy, to identify:

- TQEM external drivers
- Their business internal demand for TQEM
- Potential benefits and difficulties

- A TQEM team and allocate responsibilities
- Key areas of cost that could be reduced.

This step should result in a clear commitment statement and allocation of any resources required TQEM team with representatives from the organisation's key activities. It should receive regular reports on how the policies are implemented, and should be accountable to its stakeholders on the company's performance against the policies that are discussed below.

11.3.1.2 Step Two: Developing TQEM Policy

As soon as top management commitment is gained, TQEM policy should be developed. This policy will identify what should be done to integrate TQEM. This policy can be defined as a short public declaration that states the organisation's intentions and commitment to improve its environmental performance.

This step involves articulating the basic values that the enterprise expects its employees to follow with respect to TQEM, and setting targets for operating performance. Thus, it is the senior management's responsibility to formulate a sustainable policy. This policy should take into account economic and social as well as environmental considerations. Construction companies should incorporate stakeholder expectations into a broad policy statement that sets out the organisation's mission with respect to sustainable development. This policy statement would guide the planning process and put forward values towards which management, employees and other groups such as suppliers are expected to strive.

A draft TQEM policy should be developed at this step. It should include the requirements of ISOs by identifying the nature, scale and indicators for the company's projects and operations functions. Additionally, commitment to continual improvement, legislation and a framework for setting the objective should be established at this stage. Drafting a policy statement that is both inspirational and capable of influencing behaviour is a challenging task. However, the benefits justify the effort. Construction companies may use brainstorming or a simplistic checklist using ISO criteria. The final policy draft should be agreed by the senior management.

11.3.1.3 Step Three: Developing TQEM Plan

Once the policy has been agreed, planning activities should determine responsibilities, timeframe, costs and benefits. This plan is critical for effective TQEM in all the organisation's activities. After managers have gained an understanding of how its own operations shape up, construction companies should then consider ways to narrow the gap between the current state of the corporation's performance and its objectives for the future. A plan will need to be developed, outlining where the company hopes to position itself in the TQEM levels discussed in the previous chapter.

The contractor shall establish TQEM plan which covers the elements of the TQEM management system. This plan shall form an integral part of the company's overall TQEM plan for the respective site, project or activity, and cover specific activities with a description of what is to be delivered. The TQEM plan shall be proactive and shall be kept updated throughout the project work. The TQEM plan shall cover the occupational working environment, the design quality and environmental features, and the environment response. Separate objectives shall be defined for each of these main areas.

In addition, the TQEM plan should:

- Identify statutory rules and regulations, and other specific requirements relating to TQEM which apply to the work
- Define activities which shall be initiated to meet prevailing requirements;
- Define applicable risk acceptance criteria;
- Define the hazards which shall be addressed, how these are to be controlled, and which methods should be used if necessary to regain control;
- Identify procedures to be developed under the D&B contract;
- Define main contractor responsibilities and interfaces, and the contractor's strategy for supervising subcontractors;
- Identify and schedule the contractor's training requirements.

The TQEM plan shall be submitted to the client for review in accordance with agreed milestones. The contractor then shall be notified of possible changes to the plan.

11.3.2 Phase Two: Insuring compliance

Following the formulation of the strategy, construction companies need to ensure the compliance as a two-step process (Table 11-2): Step one: identify business legal requirements; and step two: ongoing compliance. These two steps of phase two are explained in the following sections.

11.3.2.1 Step One: Identify Business Legal Requirements

The construction sector is commonly responding to stricter quality and environmental regulation, which often inhibits growth. The results can be a trade-off between creating a healthy environment on the one hand and healthy growth on the other. Consequently, opportunities for business may be constrained. Construction companies should be aware of regulation to ensure compliance and to prevent fines and additional taxation. This is the minimum essential level. Information and data collection is critical at this step to identify which legislation applies to the organisation and in what ways and to predict forthcoming legislation.

11.3.2.2 Step Two: Ongoing Compliance

On an ongoing basis, following the identification of the legal requirements associated with their business, construction companies should commit to ongoing legal compliance. At this step the company should determine a periodic review of its legal compliance, documented as appropriate. Training requirements, emergency plans and predicting the forthcoming regulation are critical factors in this step (table 11-3).

However, ongoing compliance may take the shape of developments that are both environmentally and socially sustainable. This leads not only to a trade-off between environment and growth issues but also to an improved environment, together with development that does not draw down companies’ environmental capital. In this respect, an action plan is required to address ongoing compliance issues as well as documentation and procedures.

Table 11-3: Phase Two: Insuring Compliance

Purpose	Activities
To ascertain the principal contractors current environmental performance, legal requirements and voluntary commitments	▪ The objectives formulated above should enhance contractors' common response to strict regulation ▪ On an ongoing basis, after identifying the legal requirements associated with their business, companies should commit to ensure ongoing legal complain. (Ongoing audit here demands determining a periodically review).

11.3.3 Phase Three: Management System Implementation

Following insuring the legal requirements, TQEM techniques should be implemented effectively. Systems such as EMAS, ISOs, QS and TQM can be valuable initiatives when implemented effectively. This implementation's key elements are presented in Table 11-3. Further, an audit is required at this phase to ensure the TQEM integration. Since the quality and environmental techniques are key successful factors to support the attainment of framework objectives, the framework enhances a few systems to provide a tool together with information to equip various stakeholders for change. The following are few examples the framework suggests:

- codes, standards and guidelines, both voluntary and enforced through legislation (i.e. BS and the Code of Sustainable Building)
- best practices, applicable to almost every reform initiative around the world
- management systems, together with supporting implementation tools, specifying processes to be adopted and reported on, varying from full ISO 9000 and ISO14000 accreditation and Environmental Management Systems
- accreditation and rating systems together with supporting implementation tools
- triple-bottom line reporting schemes and methods, which are becoming increasingly common around the world (Hodgson & Milford, 2005).

Table 11-4: Phase Three: TQEM System Implementation

Phase Three: TQEM System Implementation	
Activities	**Purpose**
▪ Organisation policies ▪ Resource allocation, Information and support systems,	▪ Improving construction performance
▪ Training and development ▪ Organisation and accountability structure	▪ Using TQM and EM techniques as guidelines
▪ Reward and appraisal systems ▪ Measuring and monitoring systems	▪ Measuring the company performance against the targets.
▪ Communication and reporting ▪ Operational controls and documentation ▪ Information and support systems	▪ Auditing

Although many construction companies appear to be addressing or are accredited by the ISOs, poor implementation has limited their potential benefits. This does not mean that new management methods need to be invented. Rather, it requires a new cultural orientation and extensive implementation in terms of operations, products and services.

TQEM should be designed or revised so it is effectively aligned with the company's overall management system to achieve the following (BS ISO 14001: 1996): Organisation policies, resource allocation, operational controls and documentation, information and support systems, training and development, organisation and accountability structure, reward and appraisal systems, measuring and monitoring systems, and communication and reporting.

In this light, EMS could be used to evaluate all their operations and product functions, for example, to identify where construction 'waste' represents wasted resources or untapped opportunities. This approach should provide construction companies with an understanding of the financial costs and risks associated with integrating costly environmental programs and strategies. As such, to be implemented environmental activities may have to be justified on both environmental and a return-on-investment basis.

In conclusion, an effective integration of ISOs supports balancing economic and quality/environmental interests towards achieving sustainable competitive advantages. At this stage quality and environmental requirements could be integrated into both business planning and management information and control systems.

11.3.4 Phase Four: Stakeholder Considerations

Developing a meaningful approach to stakeholder analysis is an important role of the TQEM implemented in the previous phase. To bridge the gap between sustainability and conventional management practices, an understanding of different stakeholders is required for identifying all the parties that are directly or indirectly affected by construction activities(table 11-5).

Table 11-5: Phase Four: Stakeholder Consideration

Phase Four: Stakeholder Consideration	
Activities	**Purpose**
▪ Dialogue with each stakeholder group to reveal conflicting expectations. ▪ Stakeholder analysis can be a useful way to identify areas of potential conflict among stakeholder groups before they materialize. ▪ Auditing.	▪ Identifying the needs of various groups affected by the construction activities e.g. creditors, regulators, employees, clients, suppliers, and the community in which the enterprise operates.

D&B contractors' existence is directly linked to their clients' satisfaction. In carrying out its activities, a company must maintain respect for human dignity and strive towards a society where the global environment is protected. Although many construction companies' strategies appear to be directed primarily towards earning the maximum return for shareholders and investors, they are challenged to achieve other social and environmental objectives. Exploitation of natural and human resources is no longer acceptable. Contracting companies that are accountable only to their owners today are faced with numerous regulations governing their activities, which make their directors accountable to a broader range of stakeholders.

To conclude, the stakeholder analysis needs to consider the effect of the business's activities on the environment, the public at large and the needs of future generations.

After the stakeholders have been identified, management should prepare a description of the needs and expectations of these groups, which should set out both current and future needs in order to capture sustainable development concept. The key is to analyze how the organisation's activities affect each set of stakeholders, either positively or negatively.

11.3.5 Phase Five: Integration

Once the strategy formulation, compliance, TQEM, and stakeholder analysis have been approved as a general guides and plans, detailed plans should be prepared to indicate how the new strategy will affect construction companies' operations, supported by the appropriate TQEM techniques and programs. This phase will translate the management systems discussed in the previous section into TQEM by insuring full quality/environmental supply chain management.

TQEM issues associated with construction supply chain could be classified into four areas: (a) Produced TQEM, (b) perceived quality and environment, (c) in-bound TQEM and (d) TQEM cost. For the application of this research, TQEM integration is classified as the corporate-level TQEM (contractors business in terms of decision making and TQEM strengths and weaknesses and the financial implications) and the project-level TQEM (which includes both a procurement context and a performance context).

11.3.5.1 Corporate-level TQEM

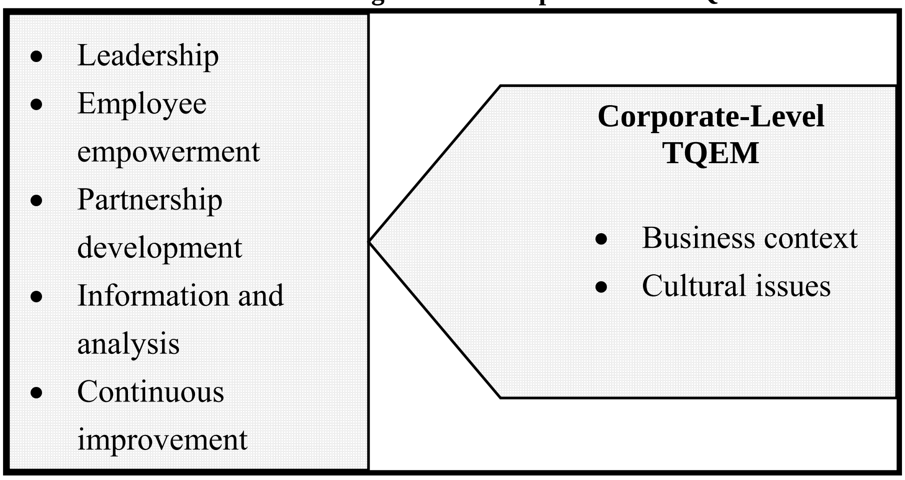
Corporate-level TQEM refers to a set of core values, revealed through the survey, that promote the delivery of increased value to customers and improvement of overall company performance and capabilities on the corporate-level. These core values are: (i) customer driven quality, (ii) environmental leadership, (iii) continuous improvement and learning, (iv)employees participation and development, (v) fast response, (vi) design quality and environmental prevention, (vii) long range view of the future, (viii) management by fact, (ix) partnership development, (x) corporate responsibility and citizenship, and (xi) results orientation.

In this sense, corporate-level TQEM refers to the vertical integration in main contractors culture and business activities (figure 11-2). Corporate-level TQEM, also, plans for the TQEM expected from subcontractors. The corporate TQEM culture is the organizational value system that encourages a quality and environmental-conscious work environment. It establishes and promotes TQEM continuous improvement through values, traditions and procedures. The existence of a strong TQEM culture should help a contractor achieve client satisfaction as well as sustaining competitive advantage by delivering higher quality and environmental projects. The corporate-level involves answering the following questions:

- Assuming responsibility for constructions entire life cycle what are the implication for project design, management and control?

- How can construction companies add value, reduce the cost through TQEM?

Figure 11-2: Corporate-level TQEM



11.3.5.1.1 Analysis of TQEM strengths and weaknesses

The analysis stage involves in the product or services and operations environmentally harmful issues in terms of product concept and identification, operations qualification and evaluation. The following tools can be used at this stage:

- Life Cycle Analysis (LCA): project related input (e.g. raw materials, energy, waste, emissions) should be quantified that will help construction companies classifying their functions input and output weight.

- Cumulative Energy Demand (CED): in terms of determining the construction operations energy demand, for example, should quantify a project energy demand over its life cycle.

- Material Input Per-Service unites (MIPS): which help in determining the energy and materials input. This quantitative determination and product environmental impact should be expressed in terms of total material input in relation to actual or potential product or service.

- Checklists: e.g. Material and Energy inputs/outputs, toxic emissions output matrix which enable estimations of the environmental impacts of a product or services and operations within the shortest possible time.

Tools that support decision-making and priority-setting include spider diagrams and portfolio diagrams, e.g. Life Cycle Analysis, PDCA or product portfolio. These tools are claimed to enable a quantitative classification of product and operations environmental quality bases such as material input, energy demand, operations method, logistics and transport product use, durability.

11.3.5.1.2 TQEM cost-accounting methods

This perspective is vital for contractors companies to recognize TQEM cost/benefit and incorporate them into the planning a decision making processes. Corporate-level TQEM in a contractor company may need to co-ordinate with costing criteria. Some examples are cost benefit analysis and economic feasibility studies throughout planning process. Profitability, marketing and technical feasibility as well as environmental and social aspects should be viewed continuously. This selection of programs, techniques and systems is required depending on organisation strategy. It may depend on the nature and scope for each organisation, e.g. industry, size, capability and resources. The degree of comprehensiveness of the analysis and the business implications of its resolution are important key factors. This section recommends some tools for analysing TQEM strengths and weaknesses and selects costing methods for TQEM. This tool benefit can be summarized as follows:

- Understanding the product cost and balancing it against the environmental related improvements during products development and production stage in terms of (marketing, planning, constriction, transport, distribution, etc.)

- Considering the environmental related costs a product a product will incur during its life cycle

- A rough estimation of the profitability of eco-improvement measures by considering the associated costs.

An example of a development process using these sustainable tools for construction that manufacture refrigerators may be summarised as follows:

- Definition of goal: the weaknesses that should be considered in this context are (a) the high-energy consumption operations, (b) the short life cycle, (c) using the ozone for cooling, (d) not good for recycling, and (e) difficult to dispose.

- Developing first ideas: some detailed points should be generated at this stage, such as dominance matrix that facilitates the definition with ranking criteria and potential improvements build upon the relevant environmental criteria.

- Implementation: based on the SPD checklists for general aspects, strategies, materials selection, resistibility, and waste minimisation.

- Co-ordination with other important criteria: multi-criteria tools should be used at this stage such as: environmental cost accounting methods.

- Research and compilation of environmental data sheets.

- Developing a detailed design and final evaluation.

Construction sector can create competitive advantages and environmental improvements by implementing ‘resource productive’ systems. Generation of a ‘Const-TQEM design mentality’ should move away from energy and material expensive production processes, design and technologies and towards a system characterised by project effectiveness, minimum-materials design and construction, scrap recovery, reuse, remanufacturing and recycling, and materials savings through better quality.

11.3.5.1.3 TQEM Culture

On the one hand, it is important to ensure that construction companies and their people give these strategies, policies, objectives and targets high concern and priority. An appropriate corporate culture is essential in this sense. On the other hand, ensuring each phase implementation is vital for continual improvement. By a process of ongoing review, companies can achieve continual improvement. TQEM culture aims to deliver innovation and more employees' participation for (a) generating new sustainable ideas, (b) effectively integrating TQEM in all the company activities and (c) increasing enthusiasm for TQEM through training and management commitment.

Changing business culture is fundamental to furthering the objectives of the framework and creating awareness of sustainability. This leads to continually reinforce the framework performance improvement message, and to broaden the awareness and understanding of TQEM towards sustainability. TQEM awareness creation could include: targeted awareness creation in the popular and technical press, award systems, such as the Considerate Contractor Scheme and the Prime Minister's Better Public Building Award and the CEEQUAL award in the UK, forums, benchmarking clubs, and demonstration projects, and periodic reporting on the state of the industry or industry reform. Staff training may be the best way for raising awareness and participation on TQEM towards sustainability.

The results of the case studies illustrate that managers' sole responsibility is to maximize the company turnover. As a result, some managers may not be accustomed to identifying the demand for TQEM in their activities such as energy efficiency and recycling. Some may never have explicitly considered the effect of their actions on any stakeholder group other than shareholders. Even multinational companies' managers appear to be thinking that it is not appropriate to redesign their programmes in order to ensure that they contribute to sustainability in developing countries.

Ongoing audit is required to question division managers and decision makers: a) is your operation in compliance? b) what progress is being made with your action plan? In turn, division managers need to be putting these questions to the plant and facility staff as well as providing senior managers with a full picture of the company performance that includes a report of all the previous phases with a time frame. Employees can have a strong influence on corporate culture and on a company's environmental performance. In other words, the concept of sustainable development requires construction sector to develop a culture that emphasizes employee participation, continuous learning and improvement.

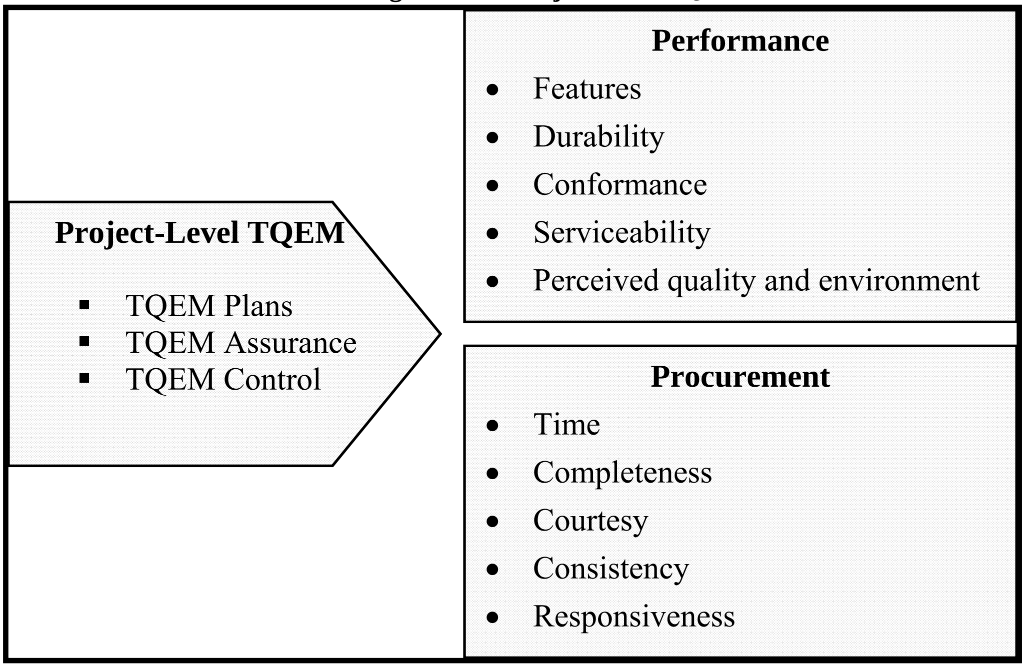
11.3.5.2 Project-Level TQEM

At the project level, TQEM tools, techniques and processes could be used to achieve organisation's project quality and environmental attributes. The refers to the project-level quality in term of materials and component management activities, project assembly on site, project management activities, and project quality systems were identified as the responsibilities of the contractor (Ofori *et al.*, 2002). The case studies undertaken by this study examined the project-level TQEM indicators in the following six areas: (i) briefing by the client, (ii) the design process, (iii) materials and component selection, (iv) project assembly on site (construction performance), (v) project management activities, and (vi) systems to promote project TQEM.

Consequently, project management functions include a) activities of managing and performing the TQEM on the project, b) training of personnel to perform quality activities, c) activities with third parties prior to delivery of products or services to assure on schedule delivery, specifically during procurement and contract expediting, d) activities of appraising and reviewing designs to find and eliminate over design and over specification, e) activities to ascertain whether design enables the most efficient construction methods to be used, and the planned construction activities are the most effective, and f) activities of inspecting, testing and checking of products/services already produced internally and externally to see if they meet requirements of material and component selection, on-site project quality, project management activities, and project quality management systems are the responsibility of the contractor.

In addition to monitoring the quality of these procured parts and equipment that are used in the construction, it is the responsibility of the contractor to select suppliers who will provide defect-free products. The actual construction process is controlled by the TQEM framework. TQEM deals with the level, complexity and completeness of the tools that are used in project management. Project-level TQEM deals quality and environmental aspects of projects' performance and procurement (figure 11-3). This figure is inspired by the total quality systems discussed in Chapter Four. Project TQEM should include the pursuit of documented practices, not tolerating deviations from plans and project controls, avoiding paramount optimism, thinking a bead in project plans and making provisions for deviations before they turn into quality problems, seeking to 'get things done right the first time' and instilling TQEM into all actions of the project team (main contractor and specialist subcontractors).

Figure 11-3: Project-level TQEM



The policies related project-level TQEM are formulated within the project strategies of individual projects which tackle performance and procurement issues. Traditionally, project strategy is driven by and involves decisions about the products, services, processes and technology, capacity, human resources, facilities, sourcing, operating systems, and quality and environmental aspects of a project organisation (Figure 11-4).

Main contractors should step back and ask two simple but critical questions 'where are the most significant waste and emission streams from our current operations?', and 'how can we reduce costs and threats through TQEM in areas such as waste minimization, energy efficiency as an immediate start and by new green technology for tomorrow's competitive advantages?'

11.3.6 Phase Six: TQEM Balanced scorecard

The introduction of a balanced scorecard can be considered as an innovation for construction by itself. Performance measurement is essential to review and evaluate for the successful integration of any framework. This is a key element of nearly all national sustainable construction initiatives. This should take place at both the "macro-level" and the "micro-level" (Hodgson & Milford, 2005). The framework approach is covering different key performance indicators in measuring achievement of the strategy objectives. A sustainable balanced scorecard is developed by this study TQEM framework with the following four perspectives: Sustainability perspective, internal business perspective, external stakeholders' perspective, and knowledge and skill perspective (Table 11-4).

Thus further measures could be enhanced depending on the project nature:

- at the macro-level the UK has instituted the Construction Industry Indicators and the Quality of Life Indicators – setting high-level performance targets for the industry together with ongoing monitoring against these targets

- at the micro-level, the UK has initiated the OGC 'Gateway' review process for acquisition programmes and procurement projects, and the CABE 'Design Review' for buildings that will have a significant impact on the environment.

Table 11-6: Balanced Scorecard

Internal Business Perspective	Knowledge and Skills Perspective
o In this perspective, construction companies should ask themselves: 'How must the organisation's management activities and processes operate in order to satisfy its stakeholders and achieve its contribution to sustainable development?' o This perspective includes issues like eco-efficiency, productivity and cost. o The functional areas that the company can control to develop its capacity required to steer their business towards sustainability as discussed in phase four.	o Learning and knowledge is a vital factor in construction seeking sustainable approach for integrating TQEM. This perspective is characterized by the question: 'How must the organisation learn, innovate and improve in order to excel at its management activities and processes and achieve its contribution to sustainable development?' o For example, performance targets may be set in terms of emission levels and energy usage per ton of output, or perhaps working hours lost due to accident or illness. o The information generated must be in the right units if actual performance is to be compared with the set targets. This might require new measuring procedures to be introduced.
External stakeholder perspective	**Sustainability perspective**
o This perspective is characterized by the question: 'How must companies be accountable to their stakeholders in order to add stakeholders value to their business, discussed in the previous chapter, and achieve its contribution to sustainable development?' o This evolves in accountability and stakeholder satisfaction. For instance, where stakeholders see success in terms of a particular level of social performance, but it is differentiated in terms of separating the organisational perspective of success from other stakeholder perspectives of success such an issue should be given a high concern on setting the company priority in considering the short and long-term goals.	o This perspective was questioned in the survey by asking: (a) 'How do you understand success for your organisation in terms of sustainable development and the goal of sustainability?' (b) 'What measures of social, economic and environmental performance are relevant?' o Relevant issues could include: (a) ecological sustainability, (b) human rights and (c) economic performance. o This perspective will be influenced by the organisation's interpretation of its contribution to SD. Contractors can use the framework phased approach to define the parameters and goals.

11.3.6.1 Sustainability perspective

This perspective is influenced by the contractor's interpretation of its contribution to sustainability. Companies can use the framework's phased approach to define the parameters and goals for its own contribution.

11.3.6.2 External stakeholder perspective

This perspective is characterized by the question: 'How can contractors be accountable to their stakeholders in order to add stakeholder value to their business?' This involves accountability and stakeholder satisfaction.

11.3.6.3 Internal perspective

In this perspective companies should ask themselves: 'How must the organisation's management activities and processes operate in order to satisfy its stakeholders and achieve its contribution to sustainable development?' This perspective includes issues like eco-efficiency, productivity, and cost, determined through. That functional areas that the company can control to develop its capacity and steer their business towards SD as discussed in phase four.

11.3.6.4 Knowledge and skills perspective

Learning and knowledge is a vital factor in companies seeking a sustainable approach for integrating TQEM. This perspective is characterized by the question: 'How must the organisation learn, innovate and improve in order to excel at its management activities and processes and achieve its contribution to sustainable development?' For example, performance targets may be set in terms of emission levels and energy usage per tonne of output, or perhaps working hours lost due to accident or illness. The information generated must be in the appropriate units if actual performance is to be compared with the set targets. This might require new measuring procedures to be introduced.

This knowledge and skills perspective tackles the skill shortage current trend facing the UK construction, as discussed in Chapter Two. This could include issues such as innovation, continuous learning, intellectual and human capital. These inter-related elements can help improve contractors' internal processes in terms of product or service and operations functions. In turn, improved internal processes can increase satisfaction for a wide range of stakeholders that will directly improve the financial bottom-line. Stakeholder satisfaction can improve companies' financial performance as well as these companies' social and environmental impacts.

11.3.7 Phase Seven: Continuous improvement culture

Continuous improvement is at the heart of TQEM towards sustainability. It is defined by the International Chamber of Commerce as; "continue to improve corporate policies, programs and environmental performance, taking into account technical developments, scientific understanding, consumer needs and community expectations, with legal regulations as a starting point and to apply the same environmental criteria internationally." Continuous improvement here could make use of some existing initiatives such as:

- the UK Construction Client Charter Improvement Programme, in which clients commit to continually improving their performance in themes

- the numerous environmental and social responsibility charters such as the Equator Principles developed by leading international financiers and the FIDIC Integrity Management System, adopted by the World Bank and others.

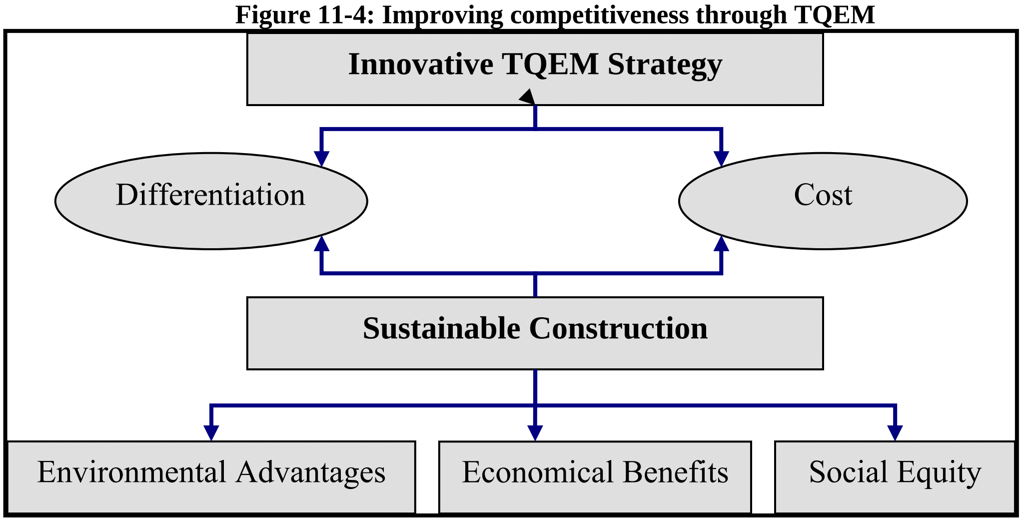
For building TQEM culture, it is important to ensure that reward and promotion systems recognize those people who contribute to the company sustainable objectives. Companies could identify some activities for raising the awareness of TQEM and sustainability concepts and implications with the use of posters, newsletters and presentations aiming to increase the awareness throughout the organisation. This awareness should be facilitated by the required training. It is equally important obtain feedback from all stakeholder representatives for continuous improvement. This ongoing process is about reviewing the current strategy in order to identify new opportunities (e.g. cost saving), enhancing TQEM implementation for improving company quality/environmental performance, establishing short- and long-term goals and developing indicators for each phase which will appear in the balance scorecard, and assessing audit steps for each phase.

To conclude, TQEM is a structural organisational learning. TQEM framework supports contractors' internal reporting systems that can have a significant effect on corporate culture. Reports must be designed to reinforce positive behaviour with respect to sustainability. Regulatory, external and internal drivers to sustainability, explained in Chapter Five, will leave them with no option but to seek good environmental practices until it becomes a culture and attitude. The road to sustainability is a long continuous process. Despite all these complex challenges, this study's approach aims to deliver cost-saving, to catch new market opportunities, avoid risks, add value and improve a company's image towards sustainability.

11.4 Challenges Ahead

Sustainability is a major challenge for the UK construction industry, as discussed in chapter5. There are three main key factors for making sustainability accessible: Strategy formulation, management changes, and building knowledge and information systems. In practice, although many believe that competitive advantages (rather than sustainable development) are the real motive for contractors to improve their environmental performance. Const.TQEM requires contractors to improve their image and achieve differentiation through developing environmental performance, increasing market share and communicating their performance to stakeholders (Figure 11-4). Therefore, by adapting a framework for TQEM contractors can tackle the following areas in terms of cost reduction: Material use (i.e. reduce components substitute materials and recycling), energy efficiency and waste minimisation. As can be seen in Figure 11-4, TQEM strategy is essential for eco-innovation that meets sustainable construction goals.

Figure 11-4: Improving competitiveness through TQEM



Main contractors are faced with the following questions: a) Does the society aware and ready to pay more for more sustainable products and services?, b) Can eco-innovation replace the ‘green wash architect’ and the strong demand on creativity and responsibility at every point of the construction value chain? and c) Will public and private clients lead the change towards sustainable buildings as it is designed? The phased approach discussed in this chapter offers a step by step approach. In this sence there are three main stages for integrating TQEM towards sustainability: pollution prevention, product stewardship and the development of clean technology. Adapting the Const.TQEM framework should fit within contractor’s strategies and should be built upon its existing quality and environmental systems. This requires aligning the TQEM with the contractor’s decision making criteria.

11.5 Guidelines for Using the Framework

This section presents Const.TQEM evaluation requirements for adapting the framework. Based on the case studies outcomes, the study’s usefulness is based on the development of Const.TQEM framework which offers a generic process for corporate and project-level TQEM implementation for improving contractors’ quality and environmental performance. The framework has potential organisational and project benefits on timing, design nature, contractor intervention, recognition, and contractual relationship. Award of the contract should consider a number of areas such as technical competence, ability to meet schedule and cost. Const.TQEM documented capability of the contractor should be clarified through the bid evaluation phase.

As part of the selection procedure, the contractor should supply details of Cost.TQEM performance history (such as providing information on their; general TQEM requirements, compliance with local laws and regulations, their technical conditions). Contractors should present their TQEM plans and relevant documentation for TQEM management systems in order to identify possible incompatibilities with their client management system. Such incompatibilities shall be clarified and resolved before contract award. Effective coordination of the various quality and environmental management systems will make it possible to develop common objectives and programs. A contract schedule should be developed. All Const.TQEM issues and deliverables, in each phase, shall be listed as part of the contract. The specific requirements used in each contract stage should be based on following:

1. Finding work: During the finding work stage of a construction company process the business development team need to discover the general level of importance placed on quality/environmental issues in both the target organisation and the market sector. Specific environmental considerations also need to be identified for individual project leads at the earliest opportunity.

2. Winning work: The procurement of work involves few specifically environmental activities. However, during the process of moving sales leads into documentation, the procurement team should seek to identify any TQEM issues that could affect the potential costs and design. These might include:

- The location of the site in relation to conservation areas that might involve delays over planning issues.
- The presence of environmentally vulnerable areas such as major aquifers, high quality watercourses, Sites of Special Scientific Interest (SSSIs), etc.
- Any formal environmental or sustainability requirements the client might have as a result of its own environmental systems or policies.
- The client's requirements for the use of specialized materials (e.g. recycled materials, timber from sustainable sources, etc.) in the project.
- The close proximity of neighbouring residential or commercial property that might be particularly affected by construction activities and which might require special controls on noise, traffic, etc.

ISO 14001 and ISO 9001 are vital to ensure full control over all the project management activities. Preparing tender submissions, due allowance must be made for any additional cost or programme implications relating to TQEM issues associated with the project.

3. Estimating and tendering: Estimating and tendering should be carried out during site visits. Where the client does not specify TQEM control requirements, the tender should include as a minimum this TQEM System (EMS & QS) and the environmental safeguards included in projects health and safety policy. The project TQEM plan must be available at time of the issue of the Contract Information sheet.

4. Pre-Construction: This stage concerns with identifying of the project TQEM aspects and impacts. Once a tender has been accepted and an operational team identified, the construction manager must review the project and, using the divisional environmental aspects register to decide TQEM aspects that must be controlled within the project. The project aspects are used for planning to ensure the company includes appropriate design initiatives and controls, has a selection of properly trained and competent sub-contractors, ensures that all sub-contractors are aware of any TQEM issues and restrictions that might affect their work, ensures that sub-contractors produce agreed TQEM controls and method statements and operate according to them, and carries out TQEM inspections and audits on site at an appropriate frequency depending on the level of TQEM risk involved.

5. TQEM considerations in design: The extent to which a contractor company controls or influences design work variables depends on the type of contract. Designs have to include any relevant TQEM planning requirements. Construction managers and design managers should aim to work with the client to minimise the environmental impacts and quality defects of the proposed building and the related construction activities. This could include some of the following, as required by the client:

- The use of recycled materials for construction.
- The use of timber from sustainable sources.
- The use of efficient energy management systems in buildings.
- Building design and orientation to control and optimise solar gain and natural light.
- The efficient use of water and the re-use of grey water where practicable.
- The effective control of site run-off to avoid pollution by spillage, including the control of fire-water run-off on relevant sites.
- Other secondary containment for storage systems if appropriate.
- Suitable facilities for waste storage, such as ground conditions, size, drainage and location.

- Identification of noise sources and provision of suitable controls where necessary to minimise potential nuisance to end-users and neighbours.

- The effective use of landscaping and natural screening.

- Suitable colour schemes for buildings.

- The presence or otherwise of aquifers and their implications for construction work and drainage arrangements.

- Any potential TQEM issues associated with the final demolition of the site buildings and the site restoration.

The previous points emphasise the importance of TQEM training to the design team. This is primarily to improve staff knowledge and offer them sustainability advice for the contractor to become qualified and for the licensed TQEM company to be able to carry out and complete assessments.

6. TQEM controls by sub-contractors: During the construction or demolition phase of a project, major TQEM issues are likely to arise through the activities of sub-contractors. Since the contractor will be held jointly liable for any environmental harm caused by sub-contractors, it will be important to maintain satisfactory control over them throughout the construction/demolition work. Project managers should therefore ensure during the pre-construction phase of any project that sub-contractors incorporate into their method statements and working practices

The six previous points highlighted Const.TQEM evaluation requirements for adapting the framework. These consideration increases the framework usefulness as a generic process for corporate and project-level TQEM implementation for improving contractors' quality and environmental performance.

11.6 Summary

Const.TQEM exemplifies the concepts of TQM and EM for contractors. This means that the compliance with the new performance-based environmental building regulation should be extended from the design phase to management, performance, and procurement.

The framework considers TQEM attributes for main D&B contractors on the corporate and project levels and the interaction among all the parties involved in a project realisation. This will allow contractors to tackle building features that may affect building performance earlier in the project and to change existing tendering procedures (tendering consortia here needs to develop design specifications rather than detailed design as part of there tender). The benefits in this case are significant cost saving (from the reduction of late costly changes in design), the early involvement of the construction team in the design process, and the minimisation of delays and disputes.

As part of this chapter, guidelines for using the framework were developed. These can allow contractors to tackle all Const.TQEM issues and deliverables, in each project phase. The specific requirements used in each contract stage should be based on following should supply details of Cost.TQEM performance history (such as providing information on their; general TQEM requirements, compliance with local laws and regulations, their technical conditions). The study's usefulness is based on the development of Const.TQEM framework which offers a generic process for corporate and project-level TQEM implementation for improving contractors' quality and environmental performance. The framework has potential organisational and project benefits on timing, design nature, contractor intervention, recognition, and contractual relationship.

CHAPTER TWELVE

CONCLUSION

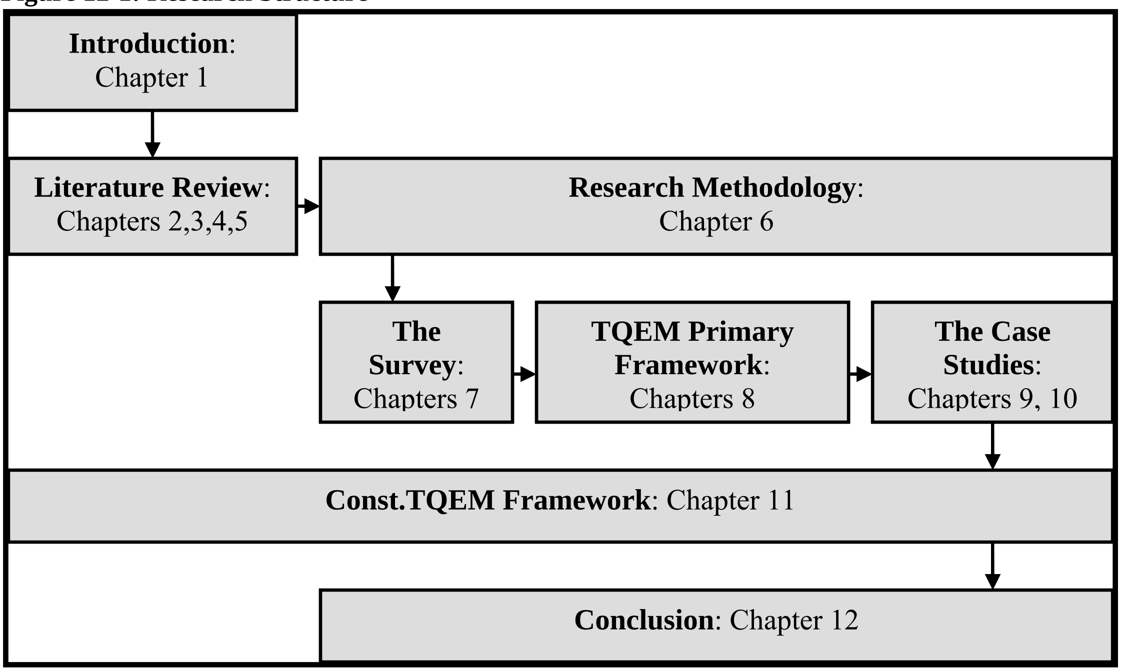
CHAPTER TWELVE: CONCLUSION

12.1 Introduction

The aim of this research is to establish the suitability of TQEM for Design-and-Build (D&B) main contractors across the major classification of project types. According to the gap in knowledge found via the literature reviewed here, the research objectives are formulated as: to establish the importance of integrating TQM and EM into TQEM towards sustainability, to find the key factors for integrating TQEM, to find the impact of TQEM, and to establish TQEM for novated D&B main contractors.

Figure 12-1 illustrates the study structure. It comprises a critical literature review and triangulation in the research methodology with data being collected from a survey and case studies. Particular consideration is given to integrating TQEM on the corporate-level (cultural and business aspects) in the survey and the operational-level (performance and procurement issues) within D&B contracts in the case studies. The research has developed a framework for TQEM applications for main contractors within novated D&B procurement route.

Figure 12-1: Research Structure



The following sections involve discussion of the previous chapters. The study's contribution to knowledge is pointed out. In this section also are the study's key findings, limitations and suggestions for further future research.

12.2 Key Findings

The research set out with the following purposes: to propagate an awareness of the importance of integrating TQM & EM into TQEM towards sustainability, to find the key factors for integrating TQEM through understanding the benefits and limitations, to investigate TQEM impact on different corporate and project level aspects, and to establish a framework for TQEM applications in construction industry. This section summarises this study's key findings. The overall hypothesis is that the integration of TQEM as an extension of the traditional holistic TQM in the UK construction companies will add value, bring competitive advantages and in turn should lead to sustainable development. The hypotheses are formulated in Chapter Five.

The research methodology for investigating the hypotheses is based on two phases. The first phase entails a survey with a purposive sample of main contractors likely to be most motivated to implement TQEM. This is initially informed by background literature and the experience of the researcher. Questionnaires were emailed to 150 top main contractors who have experienced working with D&B. The survey reports on the TQEM key factors associated with corporate-level TQEM. The second phase of investigation involves three case studies. The case companies are main contractors who have experienced working with D&B, selected by local accessibility. Based on the assumption of a design-and-build procurement method, the participants identified the project-level TQEM. All the interviews, documentation analysis and site visits were carried out between October 2006 and May 2007 and were coded for analysis.

The survey finding presents the key factors for integrating TQEM, the benefits that may occur and the barriers. The questionnaire design includes four areas: (a) company background, including the annual turnover, number of employees and the respondent title, (b) the demand and the level of implementing or addressing TQEM towards sustainability and (c) the key factors for integrating TQEM in construction companies, which includes several variables such as the standards and techniques being used, linkage to constriction stages, the associated benefits, barriers they have experienced, and (d) performance measurement towards sustainability.

Through the case studies, the survey results are linked with the construction performance and procurement (project-level TQEM). The three case studies uncover the following main issues: How could the company implement TQEM? Why had the company chosen the particular approach to quality and environmental issues in design, performance, tendering documents? How can the framework management phases be linked to construction procurement? The study's key findings support the research hypothesis, as discussed below:

1.) The survey findings are shown to support hypothesis A and therefore to confirm the underlying assumption that there is demand for TQEM in the UK construction. The case studies uncovered the reason behind that. The new environmental building regulations have a performance-based approach that requires introducing a management-based framework for action, identifying sources of knowledge and tools to improve contractors' quality and environmental performance, while considering current availability of materials and labour skill. This means that the compliance with this regulation is extended from the design phase to management, performance and procurement.

2.) In relation to hypothesis B, TQEM for the construction industry could be identified as integrating strategic environmental management into the holistic approach of TQM (continuous improvement, customer focus and team approach). For the application of this research, the steps for implementing corporate-level TQEM, as the survey shows, are: (1) Obtain the commitment of the client to TQEM, (2) general awareness and change attitudes of staff, (3) develop a process approach toward TQEM, (4) prepare project TQEM plans for all levels of work, (5) institute continuous improvement, (6) promote staff participation and contribution using TQEM control systems and (7) review TQEM plans and measure performance.

Given the prospect of project-level TQEM's high level of control over all aspects of a project – from design to commissioning – contractors can feel justified in offering a guaranteed price 'at risk' with Design-and-Build strategy, as the case studies illustrate. This risk is offset by a corresponding contractual right, afforded to them by the Design-and-Build strategy, to TQEM projects. Without the introduction of TQEM, customary under D&B arrangements, the construction work starts immediately on site before finalizing the design, based on staged building control approval. Hitherto, contractors have had the choice of employing the client's M&E consultants, or their own, or to allocate the complete package to a specialist contractor under subcontract.

An attractive aspect of this is the potential for TQEM contractor to be concurrently 'value engineered'. However, if TQEM does not specify the construction details or the output specifications, there is a risk that the quality and environment design of the completed facility may be compromised. Careful attention to the output specification is essential to achieve the required outcome.

3.) In response to hypotheses C, due to the TQEM role towards sustainability, discussed in Chapter Five, the TQEM strategy is linked to the social, environmental and economic perspectives within this study framework. There may be three complex, interconnected factors in making sustainable accessible: (A) Strategy formulation, (B) changing management for fit-to-purpose decision-making for buildings and (C) building knowledge and information systems for sustainability triple bottom lines. These elements appear to concentrate on changing the contractors' internal systems.

The survey indicates that contractors' progress of employing TQEM is still far from achieving a sustainable level (Chapter Seven). This argument supports the use of balance scorecards to achieve TQEM strategic objectives towards sustainability. As can be seen in Figure 8-2, since the TQEM main successful factors are adding value, fit-to-purpose and sustainability, the sub-tasks are therefore: Cost (i.e. project cost and contract cost), time (i.e. project time and contract time), quality (functionality, design impact, construction quality and promoting excellence and innovation), environmental responsibility, ethical sourcing and health and safety (in scope, design, construction operations, behaviour and culture), equalities: includes promoting equality and diversity, community engagement, supply chain management and employment, and financial viability: considering management structure and cost benefits (community utilization and benefits).

In developing TQEM culture in construction industry, one important step is to develop an understanding across the design team and construction team of D&B main contractor and the subcontractors who would commit to the TQEM process. Thus, the main contractor should only select subcontractors who have demonstrated quality and environmental attitude and work performance

4.) For the final hypotheses, TQEM framework for UK construction companies is developed in Chapter Eleven. Figure 12-2 illustrates the framework extended process over the project development stages, and indicates how the corporate-level TQEM phases could be linked to project-level. The procurement arrangements have been assumed to be those of a novated D&B contract. The framework considers the interaction among all the parties involved in a project. The design team starts working for the client then is 'novated' to work for the main contractor and apply for building control permissions. In this sense, TQEM phases form a part of the tendering documents leading to tackling building features that may affect building performance earlier in the project.

Corporate-level TQEM refers to a set of core values that promote the delivery of increased value to customers and improvement of overall company performance and capabilities on the corporate-level. The survey revealed corporate-level TQEM key successful factors: (i) customer driven quality, (ii) environmental leadership, (iii) continuous improvement and learning, (iv) employee participation and development, (v) fast response, (vi) design quality and environmental prevention, (vii) long range view of the future, (viii) management by fact, (ix) partnership development, (x) and corporate responsibility and citizenship.

Project-level TQEM requires an in-depth look at both construction performance and procurement system. The case studies undertaken in this study examined the project-level TQEM indicators in the following six areas: (i) briefing by the client, (ii) the design process, (iii) materials and component selection, (iv) project assembly on site (construction performance), (v) project management activities, and (vi) systems to promote project TQEM. The transformation process (i.e. the service) from resources to the constructed facility is referred to as the contracting service. The constructed facility and the contracting service form the construction project. The customer satisfaction experienced with the constructed facility and the contracting service defines project-level quality in construction.

12.3 The Research Significance and Contribution to Knowledge

This section describes the research work in terms of its originality and usefulness, and consequently the value of its contribution to the field of construction management theory. This section highlights the reasons; why this research adds to the scholarly research and literature in the field of construction management, how the study helps improve D&B contractors' practices, why the study will improve D&B contractors' quality and environmental policy and performance. This thesis makes the following contributions to knowledge:

- There are numerous titles in publication relating to individual topics presented in this thesis. However, this research has sought to bring the disparate professional subjects together in a coherent way for developing a solution for novated D&B main contractors' struggle in complying with the new environmental regulations. The research provides a holistic overview of the key principles and operating practices relating to; construction procurement, TQM, EMS, TQEM evolution in the manufacturing sector, and sustainability.

- A new concept of Const.TQEM is presented and a new framework for action is developed which identifies sources of knowledge and tools to meet performance based regulations, while considering current availability of materials and labour skill. Const.TQEM is standardized methodology for integrating TQM and strategic EM into a comprehensive lifecycle approach to construction project. Const.TQEM includes a broad range of activities aimed at improving contractors performance (corporate and project levels). It offers general engineering approach to improve the design, operation, and environmental quality of the building.

- The research originality mainly comes from refining and extending current practices of compliance with the environmental regulations from the design phase to the managerial and procurement arrangements, which considers the interaction among all the parties involved. A comprehensive approach to construction is developed as business and procurement (received by clients) and as process (received by end user).

- Research creditability is demonstrated by using the triangulation approach for observations. The triangulation approach in the study combines a survey and case studies. There are two main reasons for selecting this approach: 1) the two different methods are used for different purposes as the survey focuses on corporate-level TQEM while the case studies concern with the project-level

TQEM and 2) this use of multi-methods enables triangulation to take place in order to test TQEM primary framework for ensuring the data validity.

- This research work relevance is based on the analysis which offers a deep insight into novated D&B contractors who are motivated and have the capacity to implement TQEM. novated D&B is not only compatible with the new performance-based environmental building regulation and innovation but it is likely to be extended in the future.

- The study's usefulness is based on the development of Const.TQEM framework which offers a generic process for corporate and project-level TQEM implementation for improving contractors' quality and environmental performance. The framework has potential organisational and project benefits on timing, design nature, contractor intervention, recognition, and contractual relationship.

This study addresses the current problems of novated D&B in regulatory, procurement and intervention contexts. For a solution, adapted from manufacturing industry, TQEM management-based approach and framework for implementation are developed. Const.TQEM exemplifies the concepts of TQM and EM for the construction sector use. This means that the compliance with the new performance-based environmental building regulation should be extended from the design phase to management, performance, and procurement. The framework considers TQEM attributes for main D&B contractors on the corporate and project levels and the interaction among all the parties involved in a project realisation. This will allow contractors to tackle building features that may affect building performance earlier in the project and to change existing tendering procedures (tendering consortia here needs to develop design specifications rather than detailed design as part of there tender). The benefits in this case are significant cost saving (from the reduction of late costly changes in design), the early involvement of the construction team in the design process, and the minimisation of delays and disputes.

12.4 Potential Benefits of the Proposed Framework

Const.TQEM suggests that the functions of the framework may be split in four ways: a) as a framework that main D&B contractors can use to help them develop their vision and goals for the future, in a tangible way, b) as a framework that contractors can use to identify and understand the systematic nature of their business, project performance, procurement, the interaction between the parties involves in the project realisation, and cause and effect relationship, c) as a basis for national quality, environment and sustainability awards (i.e. CEEQUAL, Code for Sustainable Homes, BREEAM, LEED), and d) as a diagnostic tool for assessing the health of the company on the organisational and project levels.

Through this process, a TQEM contractor is better able to balance its priorities, allocate resources, and generate realistic plans with no conflict resulted from independent EM and TQM subsystems that leads to competitive demand for resources or priority attention. All these functions allow the framework to be used for a number of activities, for example, self-assessment (P-D-C-A), third-party assessment, benchmarking, and as a basis for applying for quality and environmental awards. As can be seen in Table 12-1, continuous improvement towards sustainability is at the heart of TQEM which provides many advantages for construction organisations/projects. The deployment of TQEM framework advocates that contractors needs to:

1. Determine the results it’s aiming for as a part of its policy & strategy.

2. Plan and develop an integrated set of approaches to achieve these results.

3. Integrate these approaches in a systematic way to insure implementation.

4. Review and ongoing learning activities towards sustainability.

Table 12-1: Const.TQEM advantages for contractors organisations/projects

Key Development Issues	**Possible Benefits**
Attaining TQEM organisation's objectives	Enabling the mission to be accomplished
Process approach towards sustainability	Adding value & sustainable competitive advantages
Benchmarking (Sustainable Balanced Scorecard)	(Plan-Do-Check-Act)
Action plan, focused policy & strategy	Interrelated activities systematically
TQEM corporate & project-levels integration	Management with holistic approach to decision making
D&B teams dynamics	People development & involvement
Structural organisational learning	Learning organisation

There are numerous benefits to be derived from the Const.TQEM framework for novated D&B main contractors (Figure 12-2). These benefits overcome many of the shortcomings of the conventional D&B method of construction procurement. In particular, the model provides for greater concurrency in design development and project planning. The principal benefits of this Const.TQEM framework are:

- A formal TQEM framework for identifying and prioritizing client requirements ensures that quality and environmental standards are clearly defined at an early stage and helps clients to clarify their vision of the facility to be constructed.

- The encapsulation of the client's requirements in a solution-neutral format permits tendering consortia to be innovative and to utilize their expertise and experience in formulating design solutions which satisfy all client needs, are cost effective and of very high quality.

- The large amount of rework and duplication inherent in the conventional procedure can be dispensed with, thereby shortening lead times and reducing cost.

- Delays, disputes and claims which often result from existing procedures can be reduced saving time and money.

- The new approach ensures the quality and environment of the end product since the client's requirements are well defined and can be used to check compliance and performance.

- The clear definition of client requirements at an early stage results in a reduction in uncertainty for all parties to a given construction project.

- The proposed approach of TQEM would also enable construction clients to move away from 'lowest cost' as the principal criterion for the award of construction contracts.

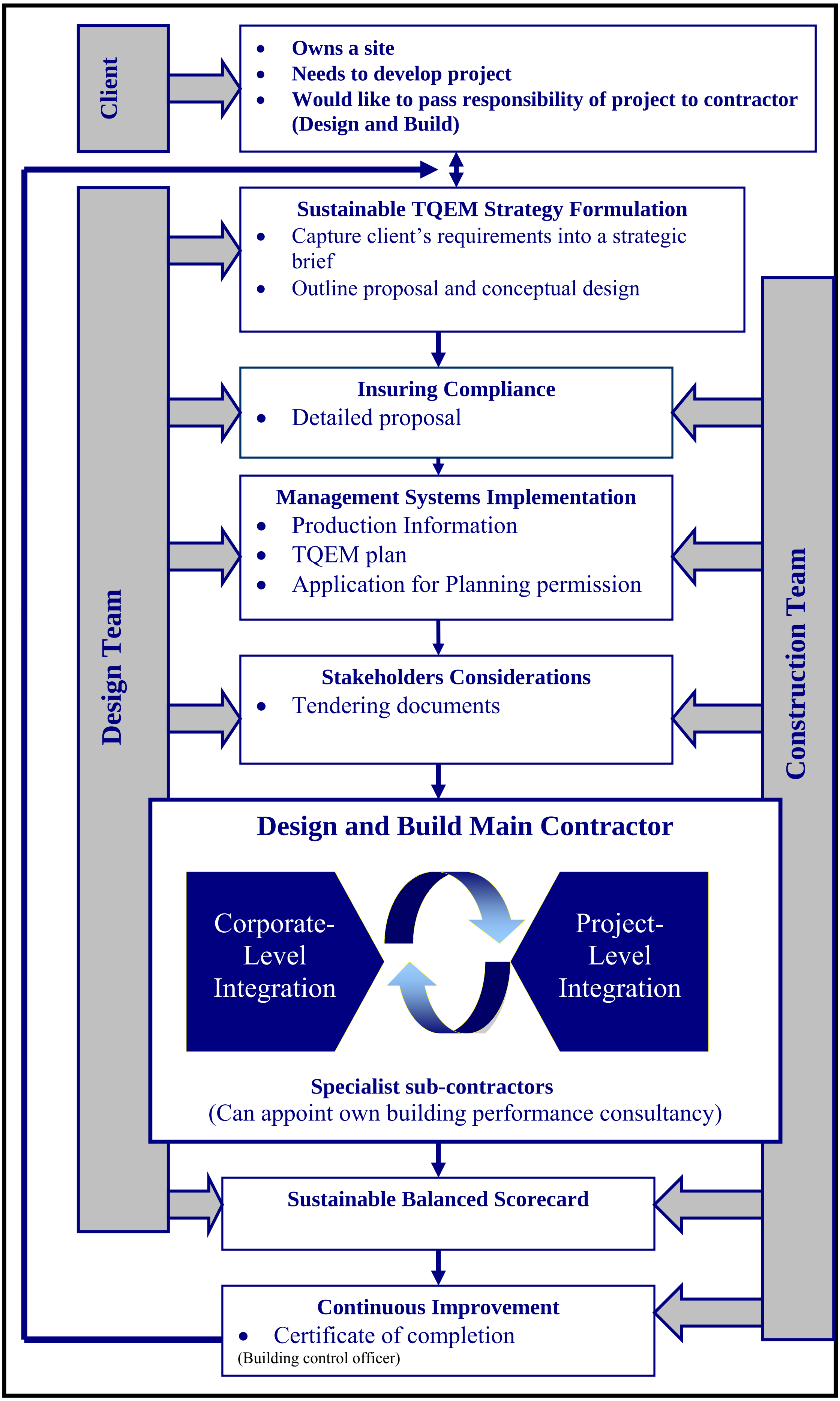
- TQEM corporative culture results in team working and group dynamics which are enhanced under the new framework process as there is an obviation of the disharmony caused by the introduction of novated consultants at the post-tender stage.

- With TQEM, better informed design decisions can be made thereby narrowing the gaps between design and performance knowledge, and between incurred and committed costs at the design stage.

- This management-based approach allows for improved communication and co-ordination between members of the project team. This was recognized, by the case studies, as vital for the construction industry.

The above benefits will result in a positive change to the business processes of the construction industry. Improving construction impact on to the built environment, as well as, resolving the age-old construction fragmentation problem are directly addressed while the TQEM implementation framework ensures the integration from the early project conception stage of the construction process through the project life-cycle.

Figure 12-2: TQEM Framework



12.5 Constraints

There are several constraints which can militate against the achievement of the above benefits of the TQEM framework. Some of the most significant of these are the adversarial culture of the construction industry and the industry's inertia to change, particularly in the adoption of new technology. To ensure survival and competitiveness, it is vital that the construction industry adopts new business processes involving TQEM in a collaborative environment. Another important issue is the need for all parties in a construction project to have appropriate representation at project team meetings. Individual project team members must be of sufficient seniority to make important decisions, but should also be fully conversant with the practical aspects of construction.

The proposed changes in the tendering procedure for novated D&B projects may also be resisted by some sections of the industry. These changes are not expected to affect the cost of tendering for D&B projects since unlike in existing procedures, where tendering consortia develop fairly detailed designs as part of their tenders. Contractors using the new process model only have to produce an outline design. In this way, the overall abortive element in tenders will be less. In any case, the overall cost of construction projects is expected to be reduced due to the significant cost savings that will result from the drastic reduction in the number of late and costly design changes, the exploitation of the project team's expertise early in the design process, and minimization of delays, claims and disputes (due to concurrent project development and shared ownership of design decisions and rationale).

This study data, survey and case studies have been collected over three years. Much time is needed to experience benefits from the implementation of the framework and to prove its validity. The collection, use and dissemination of data on the TQEM and performance of key construction systems and components in standardised 'use' settings suggest further research on the companies which has implemented TQEM framework for at least five years. This is because TQEM is a structural organisational learning towards sustainability. By comparing TQEM input and output throughout project's life cycle between different construction projects, for example, continuous improvement could be achieved. Next section will present suggestions for further research.

12.6 Recommendations and Further Research

The questions discussed in this section are ‘is it enough and what is next?’ The proposed framework within this thesis should be treated as a living document and the present study suggests further research in other substantive areas. Specific recommendations for further research are discussed below.

Although this study’s TQEM framework is very versatile, it is limited only to the planning, design and construction phases. However, significant benefits could be obtained by extending it to cover the other phases of a construction project’s life cycle (discussed in Chapter Two). This could be achieved by extending the TQEM focus to include the Post-Occupancy Evaluation (POE) and the project end life cycle. The study has focused on best practice undertaken by main contractors. The next step is to cascade this behaviour down the supply chain.

For some years, the construction industry has been keen on promoting collaborative work among the members of design and construction teams. The case study interviews clearly indicate that this has increased since the new environmental regulations and taxation were introduced. Further research should be encouraged to exchange experiences and information related to TQEM among all project stakeholders. The requirements of other stakeholders, i.e. suppliers, clients, subcontractors and occupants, could contribute to the continuous improvement of the framework. A key area for further research is the integration of the TQEM framework with the practical needs of a construction sector, its clients, suppliers and practitioners. The TQEM framework could be adapted to fit the needs of each construction market segment on the operational level.

During the course of the interviews it was noted that higher education has a role in preparing future generations capable of dealing with and integrating TQEM within the design phase. Although not directly involved in the production of projects, research and development is an important contributor to contractors’ future success. For example, it was a general theme among interviewees that higher education providers should offer a common platform for training future TQEM assessors and building control officers who are capable of dealing with building TQEM performance compliance.

Further research is needed to capture the design and construction teams' experiences as well as user requirements and experience post-occupancy evaluation, and to translate them into improved performance criteria that could be fed into regulatory revisions. Despite the relatively recent introduction of the building environmental regulations and taxation, and the exploratory nature of the current research, capturing the feedback offers the opportunity to disseminate good practice and shortfalls to practitioners, educators and policy-makers alike.

Overall, it appears likely that the environmental legislation, taxation and recognition are already having a profound effect on the contractors and procurement arrangements of UK construction projects. A number of interesting conclusions result from the study, some of which invite further examination: These include the impact of TQEM on 1) different market segment of contractors, 2) different size contractors, 3) post-construction and post occupancy evaluation and 4) collaborative working between the different parties involved in building a project.

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APPENDICES

APPENDIX A

The Cover Letter

TQEM Framework towards Sustainability

Dear Mr.

I am searching my PhD in the area of TQEM towards sustainability in the UK construction industry at the Nottingham Trent University. The research is primarily concerned with, how the shift to Total Quality Environmental Management (TQEM) could transform construction industry to sustainability. Earlier in this research, a wide survey on TQEM practices, demand and barriers was conducted and a TQEM framework was developed. I am particularly concerned with linking this TQEM framework to a construction organisation's value, supply chain, markets, projects and stakeholders.

Therefore, I should be most grateful, if your firm could take part in the next stage of this research through some phone/interviews discussion during the next month. In addition, the case study also aims to explore the feasibility of this conceptual framework, and subsequently its validation. I envisage taking up to four hours of your time over series of visits.

The project seeks ways to resolve wide range of construction management issues within an initial framework. This conceptual framework will be a practical adaptable tool that could provide participated companies with a collaborative approach for supporting integrating TQEM as a new way of thinking towards sustainability and competitive advantages.

I look forward to hearing from you if you would like to discuss this further.

Thanks in advance.

Kind regards

Lina Khadour (Msc Engineering Business Management – Warwick University)

Supervisors:

Mr. Peter Ramsay-Dawber
Head of Construction Management
School of Architecture, Design and the Built Environment, Nottingham Trent University

Prof. Roy Morledge
Professor of Construction Procurement and Director of Postgraduate Studies for the Faculty of Construction & the Environment, School of Architecture, Design and the Built Environment - Nottingham Trent University

APPENDIX B

The Questionnaire

TOTAL QUALITY ENVIRONMENTAL MANAGEMENT

1. Please state your position within the company

MD/CEO ☐ Director Executive ☐ . . . Quality/EnvironmentalManager☐ Other ☐

2. Please state the company market segment:

Housing ☐ Non-housing ☐ Infrastructure ☐ Repair & Maintenance ☐

Different Segments ☐ Other:

3. What is the number of employees in the company?

Less than 50 ☐ 51-250 ☐ 251-500 ☐ 501-1000 ☐ Over 1000 ☐

4. What is the company turnover?

<£5m ☐ £5m-£10m ☐ £11sm-£50m ☐ £51m-£100m ☐ >£100 ☐

5. How long have the company been involved with any initiatives related the following:

-Total Quality Management (TQM):

Not yet ☐ <1year☐ 1-2 ☐ 3-5 ☐ 5-10 ☐ >10 ☐

-Environmental Management (EM):

Not yet ☐ <1year☐ 1-2 ☐ 3-5 ☐ 5-10 ☐ >10 ☐

-Total Quality Environmental Management (TQEM) or linking TQM with EM:

Not yet ☐ <1year☐ 1-2 ☐ 3-5 ☐ 5-10 ☐ >10 ☐

6. How would you position your company approach on TQEM levels?

☐ Compliant: [being in compliance with environmental and building regulations].

☐ Informed:[to go beyond compliance and spend time and resources collecting information, as a key activities and participate in an external activities as a trade association].

☐ Market-Driven:[being "reactive" to your customer environmental expectations in terms of providing leading product/services and operational performance].

☐ Competitive Advantages: [understanding the environmental market opportunities and navigates to leadership market position by proactively using of knowledge].

☐ Sustainable:[proactively integration to economic growth, environmental, health and safety and social well being into its operations for long term competitive advantage].

7. Does the company accredited or addressing any of the following management frameworks related environment and quality:

Accredited : ISO14001-14004 ☐ SO 9001 ☐ EMAS ☐ BS☐ Non☐ Others:

Addressing : ISO14001-14004 ☐ SO 9001 ☐ EMAS ☐ BS☐ Non☐ Others:

8. What are the perceived benefits from applying activities associated to TQEM? (Please mark as applicable)

Cost Savings☐ Customer satisfaction☐ Market recognition☐ Increases Efficiency☐. Competitiveness☐ Productivity ☐ Better way of measuring the company environmental progress☐ Others:

9. What are the barriers for implementing TQEM? (Please mark as applicable)

Limited time and recourses☐ No customer demand☐ The implementation of EM☐ Senior management commitment☐ No clear framework for implementing TQEM & sustainability☐ The lack of performance measurement indicators ☐

No difficulties ☐ Others:

10. In your opinion which stage of construction is in demand for employing TQEM for performance improvement towards more sustainable outcomes?

Design & Preconstruction☐ Construction processes☐ Post construction☐ All construction supply chain☐ Other please specify:

11. How does your company measure its performance in terms of quality, environmental, and sustainability?

External stakeholder satisfaction perspective☐ Knowledge & skills perspective☐ Internal business perspective☐ Sustainable perspective (Social, Economic, and environmental) ☐..Other please specify:

Are you prepared to take part in some further research?

Yes☐ No☐

If you are prepared to take a part in some further research please provide your preferred contact details:

Many thanks for your time