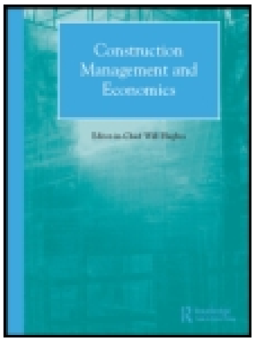

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Impact of ISO 14000 on construction enterprises in Singapore

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As construction activity has a significant impact on the environment it is vital to consider how to improve the environmental performance of organizations in the construction industry. The ISO 14000 series of standards on environmental management provides construction enterprises with the tool to address in a structured manner the adverse impacts of their operations and to attain sustainable construction. In this study, a survey was conducted to ascertain the perceptions of construction enterprises in Singapore on the impact of the implementation of ISO 14000 on their operations. Major problems were identified, and recommendations are made for the future development of environmental management systems (EMS) in the Singapore construction industry.

Keywords: Construction enterprises, environmental impact, environmental management, ISO 14000, Singapore, sustainable construction

Introduction

The need for giving greater consideration to environmental issues in the context of sustainable development has been accepted by many governments, businesses and other organizations and individuals. Several authors, such as the United Nations Centre for Human Settlements (UNCHS, 1990) and Moavenzadeh (1994), note that the construction industry affects the environment in beneficial ways, including providing the physical means for improving or protecting the environment. However, they also note that construction has detrimental effects, such as various forms of environmental pollution, resource depletion and loss of biodiversity.

The construction industry has been challenged to seek to meet the growing human needs for shelter and facilities for production, services and leisure while conserving and protecting environmental quality and the natural resource base essential for future development. As Bourdeau (1999) notes: 'The challenge for the industry is to identify new and innovative practices, technologies and ways of working which satisfy the need for a modern, competitive, efficient, responsive and socially responsible industry'. It is suggested that, to achieve this, organizational changes and targeted investment are required.

The ISO 14000 series of standards offers a framework for construction companies to manage their operations in order to improve their environmental performance and to achieve tangible results without compromising their corporate goals.

Research objectives and approach

This paper studies the impact of the ISO 14000 standards on construction enterprises in Singapore. Its objectives are to:

- determine the awareness of the ISO 14000 standards in the Singapore construction industry;

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- assess prospects for, and driving forces of, the implementation of environmental management systems (EMSs) in construction organizations;
- evaluate problems which might be encountered in implementing ISO 14000 in the industry; and
- suggest ways of promoting the adoption of ISO 14000 in the industry.

The paper is based on a questionnaire survey of practitioners. Various statistical methods were used to analyse the data.

Background

The concept of sustainability

'Sustainable development', according to the popular definition proposed by Bruntland (1987), is development which meets the needs of the present without compromising the ability of future generations to meet their needs. Although this description has been widely adopted (e.g. United Nations, 1993) several authors, including Brandon (2000), note that its practical implications are vague and poorly defined. Mullaney and Pinfield (1996) and Cecchini (2000) are among those who argue that the two terms 'sustainable' and 'development' are incompatible as development tends to destroy the ability to sustain.

Other authors, such as Richardson (1992) and Gatto (1995), read 'sustainable development' to mean that as long as development is sustained, economic growth will continue and environmental issues will be dealt with through technology, while du Plessis (2000) describes such an approach as anthropocentric, reductionist and 'mechanistic'. This runs counter to the original thinking in Bruntland's (1987) report that ecological resources should be protected, used wisely and prudently, and made renewable wherever possible. A popular recent terminology now employed by The World Bank (1999) is 'sustainable livelihood', which better accommodates the many dimensions of sustainability. It is clear that to achieve sustainability, however it may be defined, its principles must be integrated into national and corporate policies.

Moavenzadeh (1994) notes that the construction industry has played an important part in shaping society's physical environment: its output is used for production, commerce and shelter, and for providing vital utilities. However, all authors agree that construction often has a significant and irreversible impact on the environment, including the following (see, for example, CIEC, 1992; Ofori, 1992; Briffett, 1993; Griffith, 1994), the

- use of land in competition with other activities, such as agriculture;
- use of virgin land such as forests, wetlands and coastal areas, which often implies loss of biodiversity;
- massive use of natural resources, many of which are non-renewable;
- pollution of air during the transportation of materials and site activity;
- consumption of water and pollution of water reserves;
- generation of waste owing to poor resource management;
- high energy consumption on site and in completed facilities;
- generation of noise by site activity; and
- breeding of pests, such as mosquitoes and rodents, owing to poor housekeeping on site.

According to Levin (1997), buildings contribute significantly to the total environmental burden in the eight major stress categories: use of raw materials (30%), energy (42%), water (25%), land (12%) and pollution emission such as atmospheric emissions (40%), water effluents (20%), production of solid waste (25%) and other releases (13%). Cooper and Curwell (1997) estimated that, in the UK, construction uses about 6 tonnes of materials annually per capita of population. Sjöström and Bakens (1999) note that, in the European Union, buildings consume 40% of total energy, produce 30% of carbon dioxide emissions and generate 40% of all man-made waste. In Singapore, the Ministry of the Environment estimated construction wastes as 200 000 tonnes annually in the early 1990s (Ofori, 1998).

'Sustainable construction' is seen by some authors as a way for the construction industry to contribute to the effort to achieve sustainable development. For example, Sjöström and Bakens (1999) describe the efforts of the International Council for Research and Innovation in Building and Construction (CIB) to create an 'Agenda 21 for the Construction Sector'. Endeavours to develop an acceptable definition of 'sustainable construction', including an international research project by the CIB Working Commission 82 (1995), have not been successful. Bourdeau (1999) presents a summary of the CIB W82 project involving 18 countries. Contributors were asked to adopt, as a starting point, Kibert's (1994) definition of 'sustainable construction', namely 'the creation and responsible management of a healthy built environment based on resource-efficient, ecologically-based principles', and to interpret and describe its meaning in their own contexts, as well as to attempt a more relevant definition. The study found different approaches to, and priorities of, sustainable construction in different countries. Emphasis was mainly on ecological impacts, and the key elements include reducing the use of energy and the depletion of mineral resources, conserving natural areas and biodiversity, maintaining the quality of the built environment and upholding healthy indoor environments.

According to Wyatt (1994), sustainable construction involves a 'cradle to grave' appraisal, which includes managing the serviceability of a building during its lifetime and eventual deconstruction and the recycling of resources. Hill and Bowen (1997) perceived sustainable construction as consisting of four attributes ('pillars') – social, economic, biophysical and technical – supported by a set of over-arching, process-oriented principles. They recommended a framework for attaining sustainable construction that comprises the application of an environmental assessment during the planning and design stages of projects, and implementation of environmental management systems. Similarly, the UK Department of the Environment, Transport and the Regions (DETR, 1998) noted that under sustainable construction, all buildings and structures must be built in ways which are sustainable in environmental, economic and social terms as well as add value to the quality of life. It is pertinent to note that all existing definitions of 'sustainable construction' still acknowledge that, even if it were attained, construction operations would continue to have environmental impacts, although at a reduced rate.

The US Civil Engineering Research Foundation's (CERF, 1996) international survey underscored the need for construction to address the challenge of providing for basic human health and comfort in management and business practices, design technologies and practices, construction equipment, materials and systems and government policy. Latham (1994) suggested that the construction industry should identify innovative practices, technologies and ways of working which satisfy the traditional industrial demand as well as the new demands for sustainable development. The Construction Industry Research and Information Association (CIRIA, 1993, 1994) has produced reports which provide information and guidance on good environmental practice in construction.

Angioletti *et al.* (1998) present 24 criteria which define sustainable construction. The Millennium Village, UK, also illustrates aspects of sustainable construction (DETR, 1998). The development team's goals included reducing energy use in homes by 80%, cutting by 50% the energy used in building them, and reducing water demand by 30% compared with the average housing development. Developers would be encouraged to achieve similar standards.

Many industrialized countries have sustainable construction programmes (DETR, 1998). Huovila *et al.* (1998) discuss Finland's 'Environmental Technology in Construction' programme (1995–1999) which aims at developing environmentally sound methods and technologies for implementation in enterprises. It focuses on five areas: eco-balance and life cycle; design guidelines and procedures; products and production technologies; pilot construction projects; and environmental geotechnics. Bradet (1996) outlines Canada's 'Going Green' Building Programme, which promotes the use of innovative technologies and processes for existing and new federal facilities while enhancing environmental management practices within the government.

Tan (1997), Tan *et al.* (1998) and Briffett *et al.* (1998) are among researchers who have found that, despite an elaborate regulatory and administrative regime, the environmental performance of the construction industry in Singapore is poor. Existing site practices which include environmental control are weak and lead to inefficiency in resource utilization, health and safety problems and a general lack of respect for the environment.

Environmental protection in construction

The above definitions and features of sustainable construction suggest that it forms part of an effort to create a healthy built environment through resource-efficient and ecologically sound processes, preservation of ecosystems and maintenance of a balance between development and the carrying capacity of the planet.

Ofori (1992) suggested that to develop a culture of environmental protection in construction, clients should adopt 'the environment' as a 'fourth' project objective in addition to the usual ones of time, quality and cost. Ofori and Chan (1999) argued that contractual agreements between clients and contractors on environmental issues could help to achieve sustainable construction. Stenberg and Kadefors (1999) observed that since construction projects are unique, producers are not driven to invest in innovations that do not pay back in an individual project. Thus, the role of the client in 'greening' construction is vital. CIRIA (1995) advises clients to set up an environmental policy for each project and to consider environmental track records in the selection of consultants and contractors.

Barrett *et al.* (1998) show that sustainability issues cannot be fully internalized and acted upon in construction firms if sustainability is treated as a discrete problem with an isolated solution. Environmental performance improvement requires strategic focus, and an objective-nested, integrated approach involving quality, health, safety and environmental management systems. Olsen (1998) suggests that experiences in environmental management in construction in Denmark show that EMSs should be integrated with normal work processes, involve the close cooperation of all project participants, start as early as possible, be interdisciplinary and long term, and be visible throughout the building's life cycle. Emitt (1998) suggests that to attain environmentally responsible construction, all practitioners must make a commitment, change their behaviour and adopt new products, ideas and practices.

Environmental management systems

Hawken (1993) notes that, because of regulatory and competitive pressures, businesses are faced with the challenge of integrating environmental considerations into their production and marketing plans. Stigson (1998) reports on changes in policies and practices of businesses in many sectors in the industrialized countries in response to these pressures.

The construction industry must understand the nature and impact of the environmental damage it causes and take practical measures to address the problems. By corporate environmental management companies can attain a trade-off between economic growth and the sustainability of the environment. They can meet the customers' pressure for environmentally sound practices, reduce costs and avoid infringing environmental legislation. Once an organization has decided to improve its environmental performance it will need to formulate an EMS. As both Cascio (1996) and Drobny (1997) noted, an EMS is a set of management tools, principles and procedures which an organization can use to help protect the environment from the potential impacts of its activities, products, and services. The EMS outlined in ISO 14000 enables companies to adopt proactive measures to manage their processes and procedures to avoid adverse effects on the environment and to comply with the provisions of environmental regulations.

ISO 14000 series

The ISO 14000 series of standards was developed by the International Standardization Organization (ISO) in response to the trend towards sustainable development. In 1991, ISO established a Strategic Advisory Group on the Environment (SAGE) to make recommendations regarding international standards for the environment. SAGE studied major existing standards, including the British standard BS 7750, *Environmental Management Systems*. In 1993, ISO formed a Technical Committee (TC 207) to develop a uniform international EMS standard and other documents for use as environmental management tools. These were finalized in September 1996.

An EMS, as defined by clause 3.5 of ISO 14001, is the part of the overall management system which includes the organizational structure, planning activities, responsibilities, practices, procedures, processes and resources for developing, implementing, achieving, reviewing and maintaining a company's environmental policy. ISO 14000 is an evolving series of generic standards which provides organizations with the EMS structure for managing environmental impacts (ISO, 1996). Cascio (1996) observes that these standards rely on changes in organizational commitments, focus and behaviour rather than on coercion from government, and Puri (1996) adds that they provide the key to the actualization of strategic environmental management in organizations.

The ISO 14000 series incorporates five standards: environmental management systems, environmental auditing, environmental labelling, environmental performance evaluation, and life cycle assessment. ISO 14001 is an environmental management standard; it is not an environmental performance standard (ISO, 1996): it does not indicate specific performance targets.

Only ISO 14001 is a standard against which an organization can be audited, and it is voluntary (ISO, 1996). ISO 14001 is the Standard that companies will implement and the Standard to which they will either self-declare conformance or seek third-party certification (ISO, 1996). It is applicable to all types of organization in diverse geographical, cultural and social conditions. The other standards provide guidelines which support either the implementation of an EMS or the analysis of product characteristics. None of them needs to be implemented.

The ISO 14001 Standard is organized according to a five-step cycle of continual improvement, using the plan–do–check–review concept often applied in quality management (ISO, 1996): Commitment and Policy; Planning; Implementation; Measurement and Evaluation; and Review and Improvement.

By December 1997, 5017 ISO 14001 certificates had been issued, showing a growth rate of over 300% per year (ISO, 1998). Japan (1320), Germany (950), the UK (722), The Republic of Korea (463) and Denmark (347) dominate the adoption of the standards.

Efforts are underway to develop international environmental standards for construction. Soronis and Makenya (1998) and Holm (1999) discuss the work of ISO TC 59 which aims to prepare standards for an environmental assessment of buildings, utilizing the principles of the ISO 9000 and ISO 14000 series.

Benefits

Many benefits from ISO 14000 EMS implementation and certification are highlighted by several authors, including Kuhre (1995), Tibor and Feldman (1997) and Ritchie and Hayes (1998). They may be summarized as: protection of the environment; reduced operating costs; increased access to markets; demonstrated compliance with regulations; improved environmental performance; improved customer trust and satisfaction; enhanced corporate image and credibility; employee involvement and education; and potential impact on world trade to allow competition on an equal basis.

Drawbacks

Possible drawbacks of ISO 14000 adoption have been pointed out by various authors, including Tan *et al.* (1998). These include increases in short-term costs in employing environmental consultants, setting up the requisite management structures and organizing training for the firm's personnel. In particular, there can be disruptions to work flow, delays and increased costs. The need to meet continuous improvement challenges is also deemed to be onerous, especially where initial targets were achieved in the first few years. Finally, the organization's subcontractors and suppliers must also take measures to improve their environmental performance if it is to derive effective results from its EMS.

Developments in Singapore

Singapore set up an Environmental Management Technical Committee in 1994 to monitor and participate in the work of ISO TC 207. Hiang (1997) notes that the Productivity and Standards Board (PSB) initiated an ISO 14000 Pilot Scheme in 1995 under which it helped companies to test the application of the standard. The PSB ISO 14000 Certification Scheme was launched in May 1996. In that year, Sony Display Devices Singapore became the first company in Southeast Asia to be certified (Tan, 1997). Singapore was the second country in Asia (after Japan) to start certification to ISO 14001. Saniff (1997) disclosed that the Ministry of the Environment promotes ISO 14000, as it will improve the environmental performance of Singapore firms.

Tan (1997) and Tan *et al.* (1998) undertook the only studies on the perceptions of Singapore construction practitioners of ISO 14000. They found that many firms were aware of the standards but would only adopt them if to do so became mandatory. In general, contractors were only taking action to protect the environment where this was a statutory requirement. In 1998, Neo Corporation Pte Ltd became the first Singaporean construction firm to attain ISO 14001 certification. In October 1998, the Building and Construction Authority (BCA) established an ISO 14000 Certification Scheme (*Construction Focus*, 1998). For firms certified under the BCA's ISO 9000 and ISO 14000 certification schemes, the Authority will conduct combined routine surveillance audits for both quality and environmental management systems, thus reducing the number of audits. A number of construction companies are in various stages of preparation for formal certification to ISO 14001.

Field study

Research method

A questionnaire-based survey was conducted among construction enterprises in Singapore. Such a survey was suitable for obtaining the perceptions, attitudes and expectations of practitioners on the ISO 14000 series. Preparation of the questionnaire was preceded by a review of the literature on the Standards and the impact of their application.

The survey was accomplished by mail with an explanatory letter and prepaid return envelope, an efficient way to cover a large sampling base. The targeted groups were (i) clients, (ii) consultants (architects, and civil and mechanical/electrical engineers) and (iii) contractors.

The clients were selected from the 160 members of the Real Estate Developers' Association of Singapore (REDAS, 1997), architects from 24 firms listed in the yearbook of the Singapore Institute of Architects (1997), and consultants from the 58 member organizations listed by the Association of Consulting Engineers Singapore (ACES, 1997). The contractors were all the 226 firms registered in the top three financial categories (G6, able to tender for work up to SGD30 million; G7, able to tender for work up to SGD50 million; and G8, able to undertake projects above SGD50 million) by the then CIDB (1998).

The statistical software packages SPSS 8.0 for Microsoft Windows™ and Spreadsheet Excel 97™ were used to analyse the survey results. Where respondents were asked to rank factors, the Hungarian Method of Assignment was used to determine the overall ranking. Respondents were asked to indicate their views on a five-point scale (from 'unimportant' to 'most important') on the extent of certain aspects regarding the ISO 14000 Standard. In the analysis, the five points on the scale were converted into values from –2 to +2, i.e. point 3 on the scale being equal to zero.

The one-sample *t*-test was used to determine whether the mean rating of a sample is significantly different from the population mean, $\mu_x = 0$ (see, for example, McClave and Benson, 1994). The test statistics were computed using the formula

$$t = \sqrt{n}(\bar{X} - \mu_x)/S,$$

where $\bar{X}$ is the sample mean, μ_x is the population mean, S is the sample standard deviation and n is the sample size.

Due to the small number of clients and consultants who responded to the survey, their opinion could be superficial. However, a large number of contractor respondents ensured statistical robustness. As respondents were not required to provide the companies' details, the opinions given can be considered to be unbiased.

Analysis of survey results

Profile of the respondents

Of the 226 questionnaires sent to *contractors*, 33 were duly completed and returned, giving a response rate of 15%. The contractors' questionnaires were completed by a chief executive officer, managing director or assistant managing director (45%), a project manager (33%) a quality assurance manager or professional (15%), and by others (7%). Local, regional and international companies comprised 64%, 18% and 15%, respectively, of the contractor respondents. Twenty-seven respondents (82%) were specialized in building, 5 respondents (15%) focused on civil engineering, and 1 company specialized in mechanical and electrical engineering. Of respondents 58% were G8 contractors. G6 and G7 companies each constituted 21% of respondents. The majority of responding contractors (91%) had obtained ISO 9000 series certification, which in July 1999 became a mandatory requirement for registration for G6 to G8 contractors.

Nine of the 82 questionnaires sent to *consultants* were returned, a response rate of 11%. The consultants' questionnaires were completed by the principal architect/engineer or architect/engineer (67%) and manager and others (33%). Local, regional and international firms were 33%, 22% and 44%, respectively, of the companies. Of the responding consultants 44% specialized in civil and structural design, 33% focused on architectural design, and 22% undertook mechanical or electrical design or both. Of the responding consultants 22% had ISO 9000 series certification.

Of the 160 questionnaires sent to *clients*, only 11 were duly completed and returned, indicating a response rate of 7%. The clients' questionnaires were completed by a director (9%), a project manager (73%), a manager (9%) or a senior executive (9%). Local, regional and international companies constituted 36%, 36% and 27%, respectively, of the respondents. Most clients (82%) specialized in residential, commercial and industrial building. Of responding clients 36% had ISO 9000 series certification.

Although the return percentages were low, especially in the case of clients, the rates are normal in Singapore and relate to lack of interest or time, an inability to answer certain questions or because of confidentiality fears deriving from the highly competitive climate. The problem might have been exacerbated in this study by the relative novelty of the topic of ISO 14000 in Singapore's construction industry.

Awareness of ISO 14000

Three quarters of the responding *contractors* (76%) indicated that they had heard about the ISO 14000 series. They attributed their awareness mostly to the print media: newspapers (75%) and trade magazines (50%). Journals (29%) and conferences or workshops (25%) were also significant sources of information. Three-quarters (76%) of the respondents believed that an ISO 14000 EMS is relevant to the construction industry, whereas 21% of them did not consider it relevant.

All of the *consultants* had heard about the ISO 14000 standards, mainly from the print media: trade magazines (67%), newspapers (56%) and journals (33%). Another source was the internet (11%). Of contractor respondents 89% considered an ISO 14000 EMS relevant to the construction industry.

Clients were generally unaware of the ISO 14000 standards: 64% of responding clients had never heard of it. However, 55% of responding clients believed that an ISO 14000 EMS is relevant to the construction industry, perhaps based on the information on ISO 14000 provided in the questionnaires.

The industry's readiness for ISO 14000

Although, as mentioned, most contractors had heard of the ISO 14000 standards and considered them relevant to the construction industry, 67% of them felt that the construction industry was not ready for the implementation of an EMS such as the ISO 14000 series. The reasons given by the contractors for the negative response are summarized in Table 1. At the 5% level of significance, the critical values with 13 degrees of freedom are –2.1604 and 2.1604. Table 1 shows the results of the *t*-tests for all the variables. In those tests, when the computed *t*-statistics are more than the absolute critical values, the null hypotheses of mean rating equal to zero are rejected. In such cases, the variables are termed 'important'. Otherwise, if t is less than the critical value, the null hypothesis is not rejected and the variable is 'less important'. The results show that contractors rated highly the economic (costs and benefits) and commercial (such as client support) aspects, as well as practical constraints such as inadequacy of personnel.

Unlike contractors, most *consultants* (56%) felt that the construction industry is ready for the implementation of an EMS. Due to the small number of consultants who responded negatively on the industry's readiness for ISO 14000, it is not possible to determine their main reasons: all the choices of reasons were selected once or more as 'important'.

Only a quarter (27%) of the responding *clients* felt that the construction industry is ready for the implementation of an EMS such as the ISO 14000 series: 36% of them felt that they were not ready for it. Another 36% of respondents did not answer this question. For the same reasons as for the consultants, it is not possible to determine the main reason for the clients' negative response.

Reasons for ISO 14000 certification

Of the responding contractors 46% intended to seek certification to ISO 14000. However, only 40% of the contractors responding in this way felt that certification would be worth the money spent. The reasons why the contractors would seek ISO 14000 certification are shown in Table 2 (under 0.05 significance level). The contractors rated nine factors as important. The tests and classification criteria for the variables are the same as those explained above for Table 1. The top two reasons related to potential savings which could be derived (reduced wastage and avoidance of fines and taxes). They ranked as less important the effect of market forces (client's insistence and BCA requirements).

Only one consultant intended to seek ISO 14000 certification. This company believed that certification would be worth the money. None of the responding clients intended to seek ISO 14000 certification.

Promoting ISO 14000 in the construction industry

Nearly three-quarters (73%) of responding contractors, two-thirds (67%) of consultants and more than half (55%) of clients believed that environmental management would be a core requirement in the Singapore construction industry in the next century.

The Hungarian Method of Assignment (see Tan *et al.*, 1998) was used to obtain the overall ranking by the various respondents of the factors which will propel construction organizations to seek ISO 14000 certification. Table 3 shows a summary of the ranking.

Table 1 Reasons given by contractors why the construction industry is not ready for ISO 14000

Important	1.	ISO 14000 will be too costly to implement (1.143, 4.505).[a]
	2.	ISO 14000 will not bring tangible benefits (1.071, 4.372).
	3.	Benefits of ISO 14000 will not outweigh the costs of implementing it (0.857, 4.163).
	4.	Clients do not support contractors' quest for environmentally responsible operations (0.929, 3.789).
	5.	There is not sufficient qualified personnel in Singapore (0.929, 3.484).
Less important	6.	Government does not support contractors' quest for environmentally responsible operations (0.429, 1.385).
	7.	Construction firms already adopt adequate environmental measures (–0.429, –1.249).
	8.	ISO 9000 helps firms achieve the same objectives as ISO 14000 (–0.771, –0.221).

[a]Figures in parentheses are the arithmetic mean and the test statistic. n = 14; df = 13; lower critical value = –2.160; upper critical value = 2.160.

Table 2 Contractors' reasons for seeking ISO 14001 certification

Important	1.	Enable company to reduce material wastage (1.800, 16.837).[a]
	2.	Enable company to avoid infringing statutes and regulations on construction (1.667, 10.458).
	3.	Help improve workers' health, safety and welfare (1.467, 8.876).
	4.	Help company to contribute to efforts to protect the environment (1.333, 6.325).
	5.	Enhance company's public image (1.333, 6.325).
	6.	Increase company's competitiveness (1.200, 5.392).
	7.	Help to enhance company's productivity (1.133, 4.432).
	8.	Reduce company's operating costs (1.000, 3.623).
	9.	Improve company's procedures (0.867, 3.389).
Less important	10.	ISO 14000 will be essential in company's overseas drive (0.467, 1.284).
	11.	ISO 14000 will soon be made mandatory by the BCA (0.333, 0.960).
	12.	ISO 14000 soon will be insisted upon by construction clients (0.267, 0.845).

[a]Figures in parentheses are the arithmetic mean and the test statistic. n = 15; df = 14; lower critical value = –2.145; upper critical value = 2.145.

The different groups of respondents agreed on the four most important factors which will propel construction enterprises to seek ISO 14000 certification, although their ranking differed slightly. These factors are generally commercial (client demand, end-purchaser insistence and adoption by other contractors) and regulatory (requirement by government). It is pertinent to note that the client's potential importance was highlighted by all three categories of respondents. Also worth noting is the importance given by contractors to market forces as a push factor, in contrast to their indication of the importance of such forces at present (see Table 2).

Effective measures to promote ISO 14000

The respondents' views on effective measures to promote the implementation of ISO 14000 in construction are summarized in Table 4 (under 0.05 significance level); the methods for tests and classification of variables were the same as for Tables 1 and 2. Both contractors and clients ranked financial incentives as the most important promotional measure. The very low ranking for education and training by contractors is in contrast to their identification of insufficient personnel as a key constraint to the adoption of ISO 14000 (see Tables 1 and 5). All three groups of respondents indicated the importance of the

Table 3 Respondents' overall ranking of factors which will propel construction organizations to seek ISO 14000 certification

Contractor	Consultant	Client
1. If the government makes it compulsory.	1. If clients demand it.	1. If the government makes it . compulsory
2. If clients demand it	2. If the government makes it compulsory.	2. If clients demand it.
3. If end-purchasers insist on environment-friendly buildings.	3. If end-purchasers insist on environment-friendly buildings.	3. If end-purchasers insist on environment-friendly buildings.
4. If their most likely competitors become ISO 14000 certified.	4. If their most likely competitors become ISO 14000 certified.	4. If their most likely competitors become ISO 14000 certified.
5. If clients become ISO 14000 certified.	5. If clients become ISO 14000 certified.	5. If environmental pressure groups campaign for it.
6. If professional institutions and trade associations promote it.	6. If environmental pressure groups campaign for it.	6. If clients become ISO 14000 certified.
7. If environmental pressure groups campaign for it.	7. If professional institutions and trade associations promote it.	7. If professional institutions and trade associations promote it.

Table 4 Respondents' views on effective measures to promote ISO 14000

	Contractor	Consultant	Client
Effective	1. Financial incentives for ISO certified organizations (1.625, 11.038).[a]	1. Requirement for selection of designers by clients (1.667, 10.000).	1. Financial incentives for ISO certified organizations (1.250, 2.376).
	2. Tendering requirement for contractor selection by clients (1.125, 5.253).	2. Financial incentives for ISO certified organizations (1.556, 4.603).	2. Education for all construction organizations (1.000, 5.292).
	3. Support of the BCA (0.969, 5.669).		
Less effective	1. Education for all construction organizations (0.281, 1.392).	1. Support of the BCA (0.778, 1.575).	3. Requirement for selection of designers by clients (0.750, 2.049).
	2. Training of auditors and certifiers (0.125, 0.643).	2. Education for all construction organizations (0.667, 2.000).	4. Support of the BCA (0.500, 0.935).
		3. Training of auditors and certifiers (–0.111,–0.263).	5. Training of auditors and certifiers (0.250, 0.607).

[a]Figures in parentheses are the arithmetic mean and the test statistic.
Contractors: n = 32; df = 31; lower critical value = –2.040; upper critical value = 2.040.
Consultants: n = 9; df = 8; lower critical value = –2.306; upper critical value = 2.306.
Clients: n = 8; df = 7; lower critical value = –2.365; upper critical value = 2.365.

market effect (procurement requirement). Training of auditors and certifiers received the lowest ranking from all respondents.

Problems

Table 5 presents the problems which respondents believed ISO 14000 certification would pose to construction companies (under 0.05 significance level), and shows the results of the *t*-tests for the variables. Here, when the computed *t*-statistics are more than the absolute critical values, the null hypotheses of mean ratings equal to zero are rejected and the variables are considered 'most likely'. Where the computed *t* value is less than the critical value, the null hypothesis is not rejected, and the variable is considered 'less likely' where *t* is positive, and 'not likely' if *t* is negative.

The three groups of respondents did not agree on the importance of the various problems: whereas contractors highlighted personnel shortages, lack of knowledge and increased costs as the 'most likely' problems, consultants noted increased costs, lack of government and client recognition, and loss of competitiveness. Clients did not identify any particularly strong problems.

Table 5 Problems of ISO 14000 certification and implementation

	Contractor	Consultant	Client
Most likely	1. There is a shortage of personnel (1.182, 6.500).[a] 2. There is little knowledge in the industry (1.000, 5.745). 3. There will be increased costs (0.818, 4.157). 4. Changing traditional practices is disrupting and costly (0.606, 3.043).	1. There will be increased costs (1.111, 2.443). 2. The government will not recognize it (1.111, 2.857). 3. Clients will not recognize it (1.000, 3.000). 4. The company will lose its competitive edge (0.889, 2.874).	
Less likely	5. The company's employees will resist it (0.182, 1.139).	1. Changing traditional practices is disrupting and costly (0.889, 2.286). 2. There is little knowledge in the industry (0.556, 1.250). 3. It will be in conflict with the objectives of most of the company's clients (0.556, 1.250). 4. There is a shortage of personnel (0.444, 1.079). 5. The company's employees will resist it (0.444, 1.079).	1. There is little knowledge in the industry (0.875, 2.198) 2. There is a shortage of personnel (0.875, 1.698). 3. There will be increased costs (0.875, 1.698). 4. Changing traditional practices is disrupting and costly (0.125, 0.357). 5. The company will lose its competitive edge (0.125, 0.243). 6. It will be in conflict with the objectives of most of the company's clients (0.125, 0.284).
Not likely	1. Clients will not recognize it (–0.333, –1.383). 2. The company will lose its competitive edge (–0.424, –2.077). 3. The government will not recognize it (–0.515, –2.517). 4. It will be in conflict with the objectives of most of the company's clients (–0.545, –3.125).		1. Clients will not recognize it (–0.125, –0.243). 2. The government will not recognize it (–0.375, –0.753). 3. The company's employees will resist it (–0.500, –1.871).

[a]Figures in parentheses are the arithmetic mean and the test statistic.
Contractors: n = 33; df = 32; lower critical value = –2.037; upper critical value = 2.037
Consultants: n = 9; df = 8; lower critical value = –2.306; upper critical value = 2.306
Clients: n = 8; df = 7; lower critical value = –2.365; upper critical value = 2.365.

Discussion

The low overall response rate might indicate that interest in the ISO 14000 series standards and certification was low, i.e. construction firms are adopting a wait-and-see attitude towards taking up an ISO 14000 EMS. They generally consider it too early to introduce ISO 14000 in construction, although the majority of respondents believed that ISO 14000 was relevant to the industry and that environmental management would be a core requirement in future.

A high proportion of responding *contractors* intended to seek ISO 14000 certification; all already had ISO 9000 certification. Among them, 80% were G8 companies. In comparison with the 58% of respondents which were G8 firms, large organizations appear more interested in implementing EMS and in seeking ISO 14000 certification, perhaps because large firms have the necessary resources and the basic ISO 9000 certification experience to adopt an EMS.

Contractors' cost-benefit concerns influenced their attitudes to the implementation of ISO 14000. They felt it would not bring tangible short-term benefits. A major reason why contractors would seek ISO 14000 certification was that they hoped to reduce material wastage, and hence cut costs. Other reasons were to relieve the regulation burden, to protect the environment, to enhance their public image and to improve health and safety.

Contractors believed that the most effective measure for promoting ISO 14000 was financial incentives. They viewed the government as a significant driving force towards ISO 14000 adoption. Market conditions constituted another important determinant. Contractors would seek certification if clients demanded it and if end-purchasers insisted on environmentally friendly buildings. The biggest problems they anticipated in implementing an EMS were shortage of qualified personnel and a low level of awareness in the industry.

Most responding *consultants* were aware of ISO 14000. However, only one company intended to adopt a formal EMS. Consultants generally shared the views of clients and contractors regarding how to propel ISO 14000 certification in construction. Consultants' perceived obstacles to ISO 14000 implementation were increased cost and lack of recognition by government and clients.

Responding *clients* showed a low level of awareness of, and interest in, ISO 14000. Like contractors, clients believed that the government's intervention and market forces would be crucial to the adoption of ISO 14000. Promotion of awareness and financial incentives would help. The main problems of ISO 14000 implementation identified by clients were lack of knowledge within the industry, shortage of personnel and adverse effects of changes in traditional practices.

In general, construction clients, consultants and contractors in Singapore consider it too early to introduce EMS certification in construction. Market forces have not yet provided an impetus to the adoption of ISO 14000. Clients, who are in a position to set the overall environmental tone of a project, as suggested by Ofori (1992) and CIRIA (1995), lack knowledge of ISO 14000. Contractors and consultants do not expect clients to insist on an EMS, and do not think their quest for good environmental practices will be recognized by the clients. This suggests that clients have an important role in promoting the ISO 14000 EMS, for example by stipulating the institution of environmental management in the contract, as suggested by Hill and Bowen (1997).

Under the ISO 9000 quality management standards, certified firms must use certified suppliers. However, this condition is not present in ISO 14001. Consequently, the market force of ISO 14001certification relies on the emergence of a situation where firms will find their competitiveness gradually eroding unless they adopt the standard. It is good that large contractors have started to pursue ISO 14000 certification and, as a result, more firms may follow their lead.

Conclusion and recommendations

Construction has one of the highest resource uses and is responsible for pollution and much waste. Thus it imposes a considerable load on the environment. A structured approach to the improvement of the environmental performance of construction organizations is essential. The ISO 14000 EMS can help to achieve this. However, Singapore construction firms are adopting a wait-and-see attitude towards taking up the ISO 14000 EMS. There are signs that environmental considerations will cause major changes in business practices in construction in Singapore. For example, Ofori and Chan (1999) note that the environment-conscious end-purchaser and building user is likely to emerge in Singapore in the near future. Moreover, the clients' external environment may compel them to show their commitment to the protection of the environment by incorporating significant features in their projects and facilities.

All major organizations in the Singapore construction industry should be encouraged to institute EMSs such as that specified by ISO 14001. The formulation of the EMS should consider the roles of the organizations concerned at all stages of the project and incorporate measures to effectively integrate their environment-related activities.

The study showed that knowledge of the ISO 14000 series of standards within the construction industry in Singapore, while significant, is not widespread. More efforts could be made to educate construction personnel about the concepts and technical details of EMSs. The government, professional bodies, trade organizations and certification bodies should use the resources of the media to promote awareness of ISO 14000 in the industry. Professional institutions and trade associations should prepare and publicize best environmental practices to guide their members. They could also organize short courses on environmental management and its application.

Shortage of qualified personnel was considered a major hurdle to be faced by construction companies in their effort to formulate and implement EMSs. Formal educational and training programmes on environmental management in construction should be instituted. The current mandatory basic training course run by the Construction Industry Training Institute for all site personnel should also cover environmental issues in construction.

Recent studies show a low use of government incentives for promoting environmental activities in Singapore companies. For example, Nathan (1999) reports that within the last three years, only 10 companies had applied for the Ministry of the Environment's scheme which allows firms to write off capital expenditure on energy-efficient equipment in one year instead of three. Another scheme related to pollution control attracted only one applicant. It would thus appear that more publicity is required, rather than more new incentive schemes. Moreover, the continuous suitability of each incentive scheme should be maintained through regular (say, triennial) audits.

As it does not appear likely that the government of Singapore will make the institution of EMS mandatory for construction enterprises seeking to undertake public projects, market mechanisms are even more important in leading construction firms to improve their environmental performance. Ciribini and Rigamonti (1998) urge clients to select, at the prequalification stage, only contractors complying with or certified to both ISO 9000 and ISO 14000. Singapore clients could adopt this practice.

Singapore construction companies' commitment to the environment is hampered by their cost–benefit concerns. Collection and application of hard data to demonstrate the cost–benefit of ISO 14000 could help to convince companies of the business soundness of EMSs. However, the cost–benefit ratio of the adoption of environmentally responsible corporate behaviour may be unfavourable unless prices of resource inputs and waste are brought closer to their environmental costs.

The ISO 14000 series of standards offers the opportunity for construction organizations and individuals to pursue improved environmental performance in a systematic and structured manner. Their underlying premise is improvement of the organization's environmental performance in its normal operations through self-regulation and market-driven pressure. Singapore construction organizations seeking to implement ISO 14000 EMS face real challenges. Changes are required at several levels of the industry and in the companies' policies, practices and procedures.

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