INTERNATIONAL STANDARDS AND CONSTRUCTION

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ABSTRACT: This paper summarizes a research project that was conducted on the development and use of international standards and the ISO 9000 series of quality standards in the construction industry. The research investigated all aspects of international standards and included an extensive survey of members of the construction industry and members of related industries. The methods used for the study are presented along with the results obtained and an analysis of the results. The topics covered include: involvement in the development of international standards, competitiveness issues related to international standards, awareness of standards, the importance of international standards, the regulation of standards, the use of standards, the ISO 9000 registration process, the importance of ISO 9000, and results from hypothesis tests.

INTRODUCTION

International standards that will have a major impact on the competitiveness of the U.S. construction industry are being created and implemented. If new standards are not carefully monitored, their impact could negatively affect the global competitiveness of U.S. firms. The U.S. construction industry has had limited involvement and influence and has not been well-represented in the development and adoption of international standards due to the diverse nature of the agencies that create these standards. Consequently, many of the international standards being adopted may not include U.S. construction industry input.

Increasing cooperation with the international standard setting community will lead to the following:

- Increase the efficiency of developing, adopting, and maintaining international standards.
- Influence the adoption of standards that recognize the needs of the U.S. construction industry.
- Provide strategies for U.S. construction companies to remain competitive or increase their competitiveness in the global engineering and construction arena.
- Provide a service to assist in the more efficient delivery of global construction projects, such as food, pharmaceuticals, roads, bridges, water and sewer, environmental, and others.
- Reduce barriers that cause conflicts, or misunderstandings, on global projects.

A standard is a procedure, or product, used as a reference to determine the quality of similar procedures and products. It is established by determining the technical and nontechnical specifications of the procedure or product (McKechnie 1972). The ISO 9000 series of quality standards are not process standards, but they are standards that indicate that a firm has a specific type of quality system. The ISO 9000 series of standards are being implemented in the engineering and construction industry through requirements by owners for firms to be ISO 9000 series registered to specific standards.

The International Organization for Standardization (ISO) was formed in 1947 to promote the development of standardization; to facilitate the international exchange of goods and services; and to foster cooperation between intellectual, scientific, technological, and economic activities. The technical work produced by the ISO is published as international standards.

Twelve percent of the standards being used internationally, or approximately 11,000, pertain to construction. ISO, which was founded in 1947, is one of the main organizations involved in the development of standardization to facilitate the international exchange of goods and services and to foster cooperation between countries in intellectual, scientific, technological, and economic activities. In spite of the existence of ISO, and other such organizations, there is no international regulatory agency that oversees the implementation of, and compliance with, international standards. An engineering, or construction, client bidding internationally may, or may not, demand compliance with an international standard. Furthermore, registration for compliance with standards is performed by independent registrars and not internationally designated organizations or countries.

These deficiencies are not being recognized internationally and an immense effort to harmonize existing standards, and to develop new ones, is now under way in the European Community. As long as ISO standards exist, the European Community is committed to using them. Therefore, some of the standards prepared by the European Committee for Standardization (CEN) are being put forth to the ISO for adoption as world standards. The U.S. government, or U.S. private firms, have no input in the affairs of CEN. Furthermore, some U.S. standards, which until a few years ago were being used internationally, are now being discarded by countries in favor of ISO standards. Currently, the United States has limited representation in the international community for standardization. If the United States does not increase its effort to counter, or to join, the CEN effort and the efforts of other countries for the harmonization and development of world standards, the international competitiveness of U.S. construction firms will be negatively impacted.

Literature Review

The results of the literature review determined that there are no other studies on international standards and their effect on engineering and construction, nor are there any similar studies. There is a wealth of information on the topic of international standards and the ISO 9000 series of quality management standards and this information has been summarized in separate publications by the writers (Yates and Aniftos 1995).

Objectives

To remain globally competitive, it is important for members of U.S. engineering and construction firms to increase their involvement in the development of international standards. The objective of this research was to investigate the devel-

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opment and implementation of international construction standards to foster U.S. competitiveness in the global engineering and construction market.

Purpose

The purpose of this research project was to provide insight into why the U.S. construction industry should increase its participation in the development and implementation of international standards and to investigate the effects precipitated by the adoption or enforcement of international standards. The purpose was also to provide members of the construction industry with information and guidance for involvement with the international standard-setting community to improve their global competitiveness.

Organization of Study

To effectively address all of the issues related to international standards and U.S. construction industry competitiveness, this study was divided into several topic areas. This paper discusses the data collection phase and the results obtained from an extensive survey of members of the engineering and construction industry as well as related industries. The research methods utilized for this project are presented and discussed and a summary of the results obtained from the questionnaires are provided along with an analysis of the data. Conclusions and recommendations as well as areas of further study are included.

METHODOLOGY

This research investigation collected data from a variety of firms that are directly, or indirectly, related to the construction industry. The results obtained should be useful to a wide audience including those who provide construction services, as well as the clients of the construction industry.

This section describes the methodology that was used to conduct this research project. The research included the following phases:

- Phase 1: soliciting information from the 91 ISO member countries
- Phase 2: extensive literature review
- Phase 3: development of the questionnaire
- Phase 4: selection of participants for the study
- Phase 5: data collection
- Phase 6: coding and analysis of data

Phase 1—Information Solicitation from 91 ISO Member Countries

When this project was first initiated letters were sent to the appropriate organization in each of the 91 ISO member countries to obtain the following information: (1) country name; (2) institute name; (3) acronym; (4) address; (5) name of the head of the organization; and (6) types of standards used.

In addition, the letters also requested any brochures, pamphlets, or other information that describe the procedures and processes used in each country to develop, implement, and regulate standards within their country and internationally. The information provided in the letters, brochures, and pamphlets was entered into a computer database that is not included, due to its extensive size, but this information is available in the publication *International Standards: U.S. Construction Industry Competitiveness* (Yates and Aniftos 1995).

Phase 2—Literature Review

Due to the nature and extent of this study, the literature review was identified as a critical component in this research project. Pertinent literature was reviewed in the following categories:

- General information on standards—definitions, U.S. standards organizations, and international standards organizations.
- ISO standards—development process for standards, ISO 9000 series of standards, ISO 9000 registration process, steps for obtaining ISO 9000 registration, cost of registration, time requirements for registration, number of U.S. firms registered, and internationally regulated products.
- Global competitiveness and international standards—involvement in the development of standards, effects of international standards on competitiveness, and the advantages and disadvantages of international standards.

Phase 3—Development of Questionnaire

The pilot questionnaire was designed with assistance from members of the International Standards task force of the Construction Industry Institute (CII). The questionnaire contained one section for company information, one for information on international standards, and one for questions specific to the ISO 9000 series of standards.

In the first section, the firms that participated in the survey were categorized into six different categories according to (1) origin (location); (2) type of firm; (3) type of work performed by the firm; (4) annual dollar volume; (5) percentage of work in foreign markets; and (6) number of employees.

The second section contained general questions on international standards and their purpose was to provide information on the regulation and use of standards, their advantages and disadvantages, their importance, and their impact on U.S. construction industry competitiveness. These questions also provided information on the involvement of members of the U.S. construction industry in the development of international standards and their familiarity with international standards.

The third section of the questionnaire was called "ISO 9000 Series of Standards." This section of the questionnaire was used to collect information on the use and importance of the ISO 9000 series of standards, the ISO 9000 registration process, and the advantages and disadvantages of being ISO 9000 registered.

Phase 4—Selection of Participants for Study

After the questionnaire was designed and tested, the following criteria were used to determine who would be included in the survey:

1. Operations level and upper management
2. U.S. and foreign owners, constructors, engineers, suppliers, vendors, manufacturers, and ISO registrars
3. U.S. and foreign government agencies
4. Standards organizations such as ASTM, National Institute of Standards and Technology (NIST), American National Standards Institute (ANSI), Construction Industry Action Group (CIAG), etc.
5. Different business sectors including:
   - Building
   - Industrial
   - Power/process
   - Government
   - Infrastructure
6. Adequate distribution across sectors, type of business, markets, regions, etc.

Using the foregoing factors a final list was established, with

assistance from the CII International Standard's task force members, and surveys were sent to the following:

- Members of ANSI
- Members of the American Society for Quality Control (ASQC)
- Members of the Project Management Institute
- *ENR* top 150 international contractors
- ISO participating countries
- ISO registered companies

Table 1 lists the number of questionnaires received.

Phase 5—Data Collection

The final questionnaire was sent to 540 individuals during 1994. The number of completed questionnaires was 138, a response rate of 25%, which is close to the 27% considered to be an adequate response rate for this type of research. The distribution of respondents among the six categories used for the analysis of the results was also satisfactory. The six categories, and their subcategories, and corresponding number of responses for each category are shown in Table 1.

Phase 6—Coding and Analysis of Data

After the questionnaires were completed and returned they were entered into computer databases and analyzed. The next section presents the results obtained from the research and provides an analysis of the data gathered.

RESULTS AND ANALYSIS

The aim of this research project was to provide insight into the current state of international standards and the influence they have on the competitiveness of the U.S. construction industry. The material in this section reflects the views and opinions of those who participated in this research project. As such, the views presented may not necessarily represent the entire cross section of the industry, or those who are currently affected by it. However, the trends determined are accurate reflections of the views of those who contributed information to this project. The results presented are intended to be a medium of exchange of the thoughts, opinions, and ideas of those within the construction industry.

In addition to presenting the results obtained from the research project, this section also contains an analysis of the results and discussions of what the results may mean in relation to the U.S. construction industry and related competitiveness issues.

The overall responses to the questions that were included in the research questionnaire were computed and then, in order to provide additional insight into the responses obtained, the questions were categorized into eight groups according to the different topics addressed. The answers to the questions in each of the categories are summarized in the following eight tables:

- Group 1—involvement of U.S. construction industry in the development of international standards (Table 2)
- Group 2—familiarity and awareness of the U.S. construction industry with international standards (Table 3)
- Group 3—impact of international standards on the U.S. construction industry (Table 4)
- Group 4—importance of international standards (Table 5)
- Group 5—regulation of international standards (Table 6)
- Group 6—use of international standards (Table 7)
- Group 7—the ISO 9000 registration process (Table 8)
- Group 8—the importance of ISO 9000 (Table 9)

The following sections present the overall results of the survey, in the eight different categories, with general conclusions about each category provided after each table.

TABLE 1. Number of Questionnaires Received

Category (1)	Type (2)	Number of responses (3)
Category 1—origin	Domestic	114
	International	24
Category 2—type of firm	Engineering, procurement, and construction	32
	Constructor	11
	Manufacturing	55
	Design	12
	Standards professionals and registrars	16
	Miscellaneous	12
Category 3—type of work	Building construction	10
	Consulting	17
	Manufacturing	38
	Standards professionals and registrars	14
	All	33
	Miscellaneous	26
Category 4—annual dollar volume	0–100,000,000	57
	100,000,000–500,000,000	24
	500,000,000–1,000,000,000	13
	Over 1 billion	28
Category 5—percent foreign markets	0%	13
	0–25%	67
	25–50%	27
	50–100%	22
Category 6—number of employees	0–100	27
	100–200	17
	200–400	18
	400–1,000	18
	Over 1,000	54

Involvement in Development of International Standards

The results for the section of the questionnaire that pertains to the development of international standards indicate that the construction environment has changed dramatically during the last few years and awareness of the reality of the global nature of the world has also increased (Table 2). This is shown by high percentages of survey participants being familiar with international standards. Approximately half of the participants thought they knew how to get involved in developing international standards, but when asked directly most could not say exactly how to get involved and less than a third have employees that are already involved.

Designers had consistently low "yes" responses to all of the questions in this section, which may indicate that they are more insulated from the processes for developing international standards.

The results also indicate that the arena of international standards is one that is fragmented and needs a more concentrated focus. Currently, there is no single organization that represents the interests of the construction industry in the development of international standards. There seems to be a consensus that the U.S. government should take the lead in the development of international standards, but only a quarter of those surveyed would be willing to assist funding of the development of standards, and of those willing to assist most were large construction firms.

Competitiveness and project market share were cited as the main reasons for the U.S. construction industry to become involved in international standards development, with increased quality being the third most important reason. Of particular

J. Constr. Eng. Manage., 1997, 123(2): 127-137

TABLE 2. Development of International Standards

Section number-question number (1)	Question (2)	Total yes responses (%) (3)
I-3	Should the U.S. government be involved in the development of international standards?	70 Yes 69 Domestic 80 Foreign
I-9	Is there value added to participation in the development of international standards?	90 Yes 89 Domestic 94 Foreign
I-11	Does your firm have a budget for maintaining standards?	65 Yes 63 Domestic 75 Foreign
I-13	Are you familiar with the process used to develop international standards?	65 Yes 66 Domestic 62 Foreign
I-14	Do you know how to get involved in the development of international standards?	49 Yes 47 Domestic 58 Foreign
I-15	Are you involved in the development of international standards?	23 Yes 46 Domestic 33 Foreign
I-16	Does your firm have employees that are involved in the development of international standards?	34 Yes 46 Domestic 33 Foreign
I-17	Would your firm be willing to assist in funding the development of international standards?	28 Yes 28 Domestic 29 Foreign
I-23	How would you get directly involved in the development of international standards?	58 Professional society 34 Technical committee 36 Government agency
I-24	To what extent is the U.S. construction industry currently influencing ASTM and, indirectly, the International Organization for Standardization (ISO)	54 Do not know 13 said 50–75% 13 said 0–25%
I-26	Rank the following reasons for the U.S. construction industry to become directly involved in the development and implementation on international standards: (1) increase U.S. competitiveness; (2) protect market shares; and (3) increase quality	
I-30	Rank how the U.S. government should be involved in international standards: (1) sending representatives to ISO; (2) participating indirectly in the development of international standards; and (3) soliciting assistance from E&C firms and members of the industry	
I-33	Rank how the travel/time associated with the development of international standards should be funded: (1) private enterprise; (2) government agencies; and (3) consortiums of firm	

interest was the fact that private enterprise was indicated most frequently as the source of funds for developing international standards, with government agencies as the second most frequent response.

Competitiveness Issues Related to International Standards

As can be seen in Table 3 a majority of those responding, 92%, believe that international standards will have a positive long-term impact on the U.S. construction industry, which indicates that international standards are being viewed as a positive step toward globalization. The results also indicated that U.S. industries would have a competitive advantage over industries from other countries due to their superior technology and their ability to adapt quickly to changing markets.

One of the most interesting set of responses was to question I-39 where the majority of those who participated in the survey indicated that they "do not know" why their firm would be impacted by the international regulation of standards. Others responded to this question with "inability to compete in certain markets" and "inability to meet international standards due to lack of personnel ability." What this may indicate is that, of those surveyed, only a small minority really understand how international standards are currently being used and the impact they would have on their firm.

Question I-36 also verifies the participants' lack of knowledge on international standards as they ranked "increase market share" as the primary impact international standards would have on their firm. They also selected "increase documentation" and "increase regulations" as the second and third most frequent responses to question I-36.

The highest responses to what would have the largest impact on the U.S. engineering and construction (E&C) industry competitiveness were "closed markets due to particular standards," "decrease in market share due to increased competition," and "lack of versatility of personnel due to lack of familiarity with international standards." These responses demonstrate the perceived importance of international standards on competitiveness.

Awareness of Standards

Table 4 contains the results from the responses to questions on the awareness of standards. Most of the survey participants were aware of the existence of international standards, but other questions throughout the survey indicate that they were not familiar with the actual content, or procedures, used for international standards. The respondents do not understand what most of the international standards are or how to get involved in the international standards arena. Fortunately, they do want to know more about the development of international standards, those international standards already in existence, and how to directly participate in the development of international standards.

Question I-25 inquired as to the number of countries that are directly participating in ISO. Of those surveyed, 48% answered that they do not know how many countries directly participate in ISO and only 10% cited the correct answer. There are 91 countries that are members of the ISO, but there

TABLE 3. Competitiveness Related to International Standards

Section number-question number (1)	Question (2)	Total yes responses (%) (3)
I-5	Would competitiveness be negatively impacted by international regulation of standards?	14 Yes 16 Domestic 8 Foreign
I-7	Will there be long-term positive impact of international standards on the U.S. construction industry?	92 Yes 92 Domestic 92 Foreign
I-8	Will there be a long-term substantial impact of international standards on your firm?	80 Yes 80 Domestic 82 Foreign
I-29	Rank why U.S. competitiveness would increase if international standards were implemented and regulated: (1) U.S. ability to adapt quickly; (2) U.S. superior technology; and (3) U.S. economy of scale	
I-36	Rank the impact that implementation of international standards would have on your firm: (1) increase market share; (2) increase documentation; and (3) increase regulations	
I-37	Rank why your firm's competitiveness would be impacted by international regulation of standards: (1) do not know; (2) inability to compete in certain markets; and (3) inability to meet international standards due to lack of technology	
I-39	Rank the following in order of largest impact on U.S. E&C industry competitiveness if the U.S. construction industry is not involved in the development and implementation of international standards: (1) closed markets due to particular standards; (2) decrease in market share due to increased competition; and (3) lack of versatility of personnel due to lack of familiarity with international standards	

TABLE 4. Awareness of Standards

Section number-question number (1)	Question (2)	Total yes responses (%) (3)
I-25	Do you know how many countries have a government agency that directly participates in the International Organization for Standardization's move to develop international standards?	48 answered "Do not know" (54 domestic, 52 foreign), 10 indicated the correct answer (32) (8 domestic, 17 foreign)
I-40	Which areas would you like to know more about related to international standards: (1) the development process for international standards; (2) international standards already developed; and (3) participation in the development of international standards	
II-1	Are you familiar with the ISO 9000 series of quality standards?	93 Yes 93 Domestic 96 Foreign

are only 32 countries with technical secretariats that have participant (P) status. The remaining countries only currently have observer (O) status.

General familiarity with the ISO 9000 series of standards was expected as most trade publications, or professional journals and magazines, have mentioned this series of standards. Many individuals do not understand how the registration process works, how it is enforced, and why it is so important.

Importance of International Standards

Table 5 contains the results to questions on the importance of standards and their benefits. As the unanimous responses indicate, there is no doubt as to the increasing importance of international standards and their benefit to organizations. Yet, of those surveyed, only 40% had any type of global strategy on standards, with more foreign firms having global strategies (52%) than U.S. firms (38%). But, as was indicated in other questions in the survey, many firms leave the management, maintenance, and distribution of standards to their quality departments, or their engineering design departments, which indicates that their strategies may not be totally global.

Less than half of the survey participants would be willing to sacrifice variety to standardize products. Companies make money with unique designs; therefore, members of U.S. firms believe that they would not be as competitive if designs were standardized.

The major benefits to the U.S. construction industry cited for the implementation and regulation of international standards address general policy issues rather than competitiveness or market share. "The removal of technical barriers of trade," which was ranked as the number one benefit to international standards, would allow firms from many countries to compete on a more level basis. "Improving universal technical communications and mutual understanding," which was ranked second, would also achieve the same results as the number one ranked benefit, and "Facilitation of the international exchange of goods" is also a benefit to all of those competing in an industry.

Regulation of Standards

Forty percent of the survey participants indicated that international standards should be mandatory for engineering and construction, but when this is compared to question I-4 ("would one set of international standards be beneficial to your organization?"—92% "yes") it appears that if they are given a free choice on using international standards then they would be more acceptable than mandatory standards to those who participated in this study. Even though the majority of the respondents do not want mandatory standards, 74% indicated that the regulation of standards would increase U.S. construction industry competitiveness (Table 6).

The major confusion on international standards surfaces in question I-22—"who currently enforces international standards?" The ISO was indicated by 52 respondents, international organizations by 27, the U.S. government by 8, and "do not know" by 8. The most accurate responses would be U.S.

J. Constr. Eng. Manage., 1997, 123(2): 127-137

TABLE 5. Importance of Standards

Section number-question number (1)	Question (2)	Total yes responses (%) (3)
I-1	Will international standards increase in importance with time?	100 yes, both domestic and foreign
I-4	Would one set of international standards be beneficial to your organization?	92 Yes 93 Domestic 86 Foreign
I-18	Does your organization have a global strategy on standards?	40 Yes 38 Domestic 52 Foreign
I-19	Would your firm be willing to sacrifice variety to standardize products?	48 Yes 40 Domestic 44 Foreign
I-34	Rank the major benefits of the development, implementation, and regulation of international standards for U.S. industries: (1) the removal of technical barriers; (2) improvement in universal technical communications and mutual understanding; and (3) facilitation of the international exchange of goods	

TABLE 6. Regulation of Standards

Section number-question number (1)	Question (2)	Total yes responses (%) (3)
I-2	Should international standards for engineering and construction be mandatory?	40 Yes 38 Domestic 50 Foreign
I-6	Would the regulation of international standards increase U.S. construction industry competitiveness?	74 Yes 72 Domestic 91 Foreign
I-10	Does the formation of the EEC increase the necessity of international standards?	82 Yes 72 Domestic 91 Foreign
I-22	Who do you think currently enforces international standards: (2) International Organization for Standardization (52); (2) not enforced (35); (3) international organizations (27); (4) other (22); (5) U.S. owner organizations (14); and (6) other (8)	
I-32	Rank the drivers to the development and implementation of international standards: (1) European Economic Community formation; (2) owner and client requirements; (3) industrialization of developing countries; (4) U.S. and foreign government intervention; and (5) other and do not know	

owner organizations and others, but currently no agency actually enforces international standards. International standards can be stipulated in contracts or required by owners for bidding on a project.

The drivers listed to the development of international standards indicate that European participation is considered the primary driver. The other drivers cited were all diverse, which indicates that the respondents may not have the depth of understanding required to properly answer this question, or the main driver could be unnamed fears about the consequences of international standards.

Use of Standards

The responses listed in Table 7 address issues related to how international standards are being used in the E&C industry. More than half of the domestic firms in this study cite non-U.S. standards; however, from the other categories of questions, there is a clear indication that they are not very familiar with international standards, or how they are created and adopted.

The majority of international standards being used are quality standards, yet the majority of international standards are in the product area that was cited with quality standards and less frequently cited alone. This correlates to the responses to question I-27, which indicated that quality departments are the most frequently cited department responsible for the maintenance of standards, with engineering departments being listed second, management third, and standards departments fourth. Once again this is contradictory to the fact that the number of quality standards is low compared to other standards, yet they are the ones that demand the most attention.

The results to question I-28 differed between domestic and foreign respondents. U.S. E&C personnel rely on professional society publications to be notified about new standards and foreign personnel use special standards publications and government publications.

Question I-31 supports many of the previous responses as the top ranking impact on influencing the United States to develop and use international standards was the need to operate globally—even though international standards are not currently mandatory.

There is still a great deal of confusion on quantifying the savings from using quality standards as the highest ranking response to the question on how to measure the savings due to quality standards was "increased quality," which is difficult to actually measure. This response was followed by reduced costs and reduced time. When asked to indicate the actual savings from the use of quality standards most firms could not quantify them in dollar amounts. The major savings cited were being able to use standards in lieu of detailed specifications or drawings.

ISO 9000 Registration Process

The results shown in Table 8 were only obtained from members of firms participating in this study who were already registered in the ISO 9000 series of standards. Questions II-3 and II-4 show that the survey respondents prefer to not have only one organization responsible for registering firms in ISO 9000.

TABLE 7. Use of Standards

Section number-question number (1)	Question (2)	Total yes responses (%) (3)
I-20	How often do you cite non-U.S. standards?	0–25 (62) 25–50 (13) 50–75 (23) 75–100 (6) 100 (6) Do not know (9) Not applicable (7)
I-21	What type of international standards do you use?	Quality (63) Quality, process, product (55) Product (25) Process None (9) Do not know (3)
I-27	Rank who in your firm is responsible for the maintenance of standards: (1) quality control department; (2) engineering department; (3) management; (4) standards department; (5) standards individual; (6) do not know; and (7) other	
I-28	Rank how employees of your firm are notified of new standards: (1) special standards publications; (2) professional society publications; (3) trade publications; (4) government publications; (5) ASTM publications; (6) National Institute for Standards and Technology (NIST) publications; (7) other; and (8) do not know	
I-31	Rank the following as to their impact on influencing the United States to develop and use international standards: (1) need for standards to operate globally; (2) other countries using ISO standards; (3) keep up with other organizations developing standards; (4) efficiency of procedures; (5) other countries contributing funds for the development of international standards; (6) do not know; and (7) other	
I-35	Rank the ways our company qualifies cost savings from quality standards: (1) increase quality; (2) reduce costs; (3) reduce time; (4) reduce personnel; (5) do not know; (6) increase quality/increase costs; and (7) other	
I-38	Rank the major savings if most products had international standards: (1) reference to standards in lieu of detailed specifications on drawings; (2) do not know; (3) retrieval times in design and engineering; (4) reduced ordering costs, storage space, and handling requirements; (5) use of standard stock items in lieu of new items; (6) larger manufacturing and purchasing quantities; (7) reduced tied-up capital in stores and production; (8) reduced safety storage (backup stock) in view of shorter delivery times; and (9) other	

The long lead times that currently exist—anywhere from half a year to a year—for a register to audit and register a firm also support the need for multiple registrars.

The responses to question II-14 were encouraging as a large portion of the firms ISO 9000 registered were able to retain some or all of their previous quality systems, which helps reduce the costs associated with becoming ISO 9000 registered.

The costs for obtaining ISO 9000 registration varied dramatically as indicated in question II-15. The question did not indicate whether these were directly accountable costs or whether they were also including training costs in their numbers, which may explain some of the wide variation in costs, with over half of the participants indicating costs of over $50,000.

As for the time required to become ISO 9000 registered, the average time was between 15 and 20 months. The number of staff involved in the ISO 9000 registration process fluctuated with the size of the firm seeking registration, with most firms having less than 20 staff members directly involved.

In the area of scope of certification, the responses varied between the United States and foreign firms. The scope of foreign firms registration included engineering design; construction; and products, process, and quality. U.S. firms primarily covered products, processes, and quality; quality; engineering design; and processes.

Importance of ISO 9000

The responses in Table 9 support the perceived importance of the ISO 9000 series of standards. The majority (81%) of firms responding to the survey plan on becoming ISO 9000 registered at some point in the near future. Ninety-two percent indicated that the implementation and regulation of the ISO 9000 series of standards would increase U.S. competitiveness, yet only 49% would be willing to trade higher production costs for higher quality.

As far as the actual requirements for being ISO 9000 registered are concerned, it is still in limited use. Only 11% of those responding to the survey have been eliminated from bidding because they were not ISO 9000 certified and only 8% have eliminated contractors for not being ISO 9000 certified.

For this study, 52% of the firms of the respondents were already ISO 9000 certified and 49% indicated their volume of work had increased because they were ISO registered. Of those already ISO 9000 registered, 98% plan to continue being registered in the future. For firms that were not ISO 9000 registered, the primary reason was that it is not required in their industry. Many firms were preparing for certification and several respondents felt there was no benefit to being certified.

The major advantage cited for using the ISO 9000 series of standards confirmed many of the responses to previous questions as the reasons to protect worldwide market share, to facilitate doing business worldwide, and to have a competitive advantage over other companies that are not fluent in international standards were ranked first, second, and third, respectively.

RESULTS FROM HYPOTHESES TESTS

To determine whether there were differences between the responses obtained from the different categories of survey respondents five hypotheses were developed and tested using analysis of variance tests and Duncan's test. Duncan's test is used to determine which of the variables varies the most from the other variables. The following hypotheses were tested:

1. There will be no significant difference among the survey

J. Constr. Eng. Manage., 1997, 123(2): 127-137

TABLE 8. ISO 9000 Registration Process

Section number-question number (1)	Question (2)	Total number of responses (3)
II-3	Should certification to the ISO 9000 series of standards be performed by only one regulatory agency rather than multiple registrars?	27% Yes 25% Domestic 36% Foreign
II-4	Should certification to the ISO 9000 series of standards be performed only by the International Organization for Standardization or another agency?	34% Yes 30% Domestic 44% Foreign
II-10	What quality assurance system do you currently use?	ISO 9000 quality procedures (77) Total quality management (50) In-house system (46) Other (14)
II-14	How much of your previous quality system was retained when you became ISO 9000 registered?	75–100% (19) 100% (14) 0–25% (11) 50–75% (11) 25–50% (8) 0% (2) Do not know (2)
II-15	What was the approximate cost of obtaining ISO 9000 registration?	$10,000–$20,000 (12) $50,000–$100,000 (11) $200,000–$300,000 (11) $20,000–$30,000 (7) $100,000–$200,000 (7) $30,000–$40,000 (6) Do not know (5) $5,000–$10,000 (2) Over $500,000 (2) $300,000–$400,000
II-16	Approximately how long did it take your firm to become ISO 9000 registered?	12–16 months (17) 16–30 months (13) 11–12 months (8) 20–24 months (6)
II-17	How many members of your staff were involved in the ISO 9000 certification process?	5–10 (14) 10–20 (13) 0–5 (12) Over 300 (8) 20–30 (5) 50–60 (4)
II-18	What is the extent of certification (number of offices)?	1 (21) 2 (12) 3 (6) 4 (3) 5, 6, 12, 15–20, 20–30 (all 2 each) 7, 8, 9, 10 (all 1 each) Do not know (3)
II-19	What is the scope of your certification?	Products, process, and quality (32) Engineering design (25) Quality (21) Process (14) Construction (9) Products (7) Products and process (3)

responses based on the location of the respondents concerning their perceptions on international standards.

2. There will be no significant difference among the survey responses based on the type of firm of the respondents concerning their perceptions on international standards.
3. There will be no significant difference among the survey responses based on the type of work of the respondents concerning their perceptions on international standards.
4. There will be no significant difference among the survey responses based on the annual dollar volume of the firm of the respondents concerning their perceptions on international standards.
5. There will be no significant difference among the survey responses based on the percentage of work in foreign markets of the firm of the respondents concerning their perceptions on international standards.
6. There will be no significant difference among the survey responses based on the number of employees in the firm of the respondents concerning their perceptions on international standards.

Hypothesis One

The majority of variables for this hypothesis were found not to be significantly different at both the 0.05 and 0.01 level; therefore, hypothesis one was accepted.

Hypothesis Two

Only four questions were found to be significantly different in this category—sections I-1, I-13, I-14, and I-15—the last three of which deal with the processes required to develop international standards. Since only four questions were found to be significantly different, hypothesis two was accepted.

When Duncan's test was performed on this test data there were several questions where the participants varied according to the respondents' type of firm. For questions where the responses showed that one type of firm differed substantially, the type of firm was a standard body, professional society, or registrar—all of which differed on the question of how to get involved in the development of standards. These organizations are currently more directly involved in the development of standards; therefore, their personnel have more knowledge about this area.

One of the most important differences was in section I-13 where members of design firms differed from most of the other respondents. This question asked whether they were familiar with the process to develop international standards. The responses obtained indicate that designers have the least knowledge on the development of international standards, yet they are the ones who are the most directly affected by the adoption and implementation of standards.

Hypothesis Three

For this group of questions there were only five questions that were significantly different when they were compared by the type of work of the firm of the respondents; therefore, this hypothesis was also accepted. The results obtained from Duncan's test again indicated that standard bodies, professional societies, and registrars differed the most from the other respondents when their responses were analyzed by the type of work performed by the firm.

Hypothesis Four

The fourth hypothesis was accepted as only four questions were significantly different when compared by the annual dollar volume of the firm of the respondents. When Duncan's test was performed on the results in this category several different questions had responses that differed.

The results of this analysis indicate that firms classified as smaller according to their annual dollar volume are not as concerned with the introduction of new international standards, or in the development of international standards, as their counterpart larger firms. Section I-8 inquired as to whether international standards would have a long-term substantial impact on a firm. Members of the smaller firms responded that they did not think international standards would have a long-term substantial impact on their firms. The smaller firms also do not feel there is value added to participation in the development of standards, yet they do not know how to get involved in the development of standards, and they are not currently in standards developments. These types of responses could also indicate that the members of smaller firms have had less ex-

TABLE 9. Importance of ISO 9000

Section number-question number (1)	Question (2)	Total yes responses (%) (3)
II-2	Is your firm considering becoming ISO 9000 registered in the future?	81 Yes 78 Domestic 94 Foreign
II-5	Do you think that the implementation and regulation of the ISO 9000 series of standards would increase U.S. competitiveness?	92 Yes 92 Domestic 89 Foreign
II-6	Would your firm be willing to trade higher production costs for higher quality?	49 Yes 45 Domestic 65 Foreign
II-7	Have you eliminated from bidding because it is not ISO 9000 certified?	8 Yes 7 Domestic 14 Foreign
II-8	Has your firm been eliminated from bidding because it is not ISO 9000 certified?	11 Yes 7 Domestic 14 Foreign
II-9	What percentage of your clients currently require ISO 9000 certification?	0 (36) 0–25 (54) Do not know (16) 25–50 (9) 50–75 (4) 75–100 (3) 100 (2)
II-11	Are you already certified to the ISO 9000 series of standards?	52 Yes 53 Domestic 50 Foreign
II-12	Has your volume of work increased due to being ISO registered?	49 Yes 53 Domestic 50 Foreign
II-13	Do you plan on continuing to be ISO 9000 registered in the future?	98 Yes 98 Domestic 100 Foreign
II-21	If you are not ISO 9000 certified rank the reasons are: (1) not required to in our industry; (2) preparing for certification; (3) do not benefit from being certified; (4) other; (5) cost is prohibitive; and (6) do not know	
II-22	Rank the following advantages to U.S. firms for using the ISO 9000 series of standards: (1) protect worldwide market share; (2) facilitates doing business worldwide; (3) have a competitive advantage over other companies that are not familiar with international standards; (4) participation in the international standards process will allow U.S. firms to help shape international standards; (5) other; and (6) do not know	
II-23	Rank the major disadvantages of using the ISO 9000 series of standards: (1) additional costs to modify work procedures; (2) additional costs to revise standards; (3) additional costs to modify work processes; (4) other; (5) additional costs associated with the disruption of business and employee morale; and (6) do not know	
II-24	Rank how your firm quantifies the savings due to registration: (1) improved quality; (2) increased market share; (3) increased productivity; (4) increased profit; (5) other; (6) reduced production time; (7) reduced documentation; and (8) do not know	
II-25	Rank the reasons your firm obtained ISO 9000 registration: (1) to meet client requirements; (2) to standardize within the firm; (3) to work in foreign market; (4) to improve company documentation; (5) to reduce costs; (6) other; and (7) do not know	

posure to this area and, therefore, do not realize the importance and the long-term impact of international standards.

Hypothesis Five

Only two questions were significantly different when compared by percentage of work in foreign markets; therefore, hypothesis five was also accepted. Companies with 0% work in foreign markets differed the most from the other groups of respondents. The responses obtained from members of firms that did not have any work in foreign markets differed the most on questions related to involvement in the development of international standards, the impact of international standards on U.S. construction industry competitiveness, the importance of international standards, and the ISO 9000 process.

The differences that are highlighted by the results of Duncan's test for this hypothesis again indicate that in addition to smaller firms, firms that do not have direct contact with foreign markets, or foreign firms, have the least knowledge on international standards and are not currently concerned with how international standards would ultimately affect their firms. Since their work is primarily domestic they assume that they can continue to operate using U.S. standards and do not have to be aware of what is taking place in the international arena. This could change if U.S. owners, or foreign owners who operate in the United States, choose to adopt international standards or require them for their projects.

Hypothesis Six

For this hypothesis only one question was found to be significantly different when the responses were analyzed according to the number of employees in the respondents' firms. Duncan's test indicated that the responses differed on only three questions—I-4, I-5, and I-7—which inquired as to whether one set of international standards would be beneficial to their firm, whether competitiveness would be negatively impacted by the regulation of international standards, and whether there would be a long-term positive impact of international standards on the U.S. industry. The major variation in responses was between firms that had 0–100 employees and those that had 400–1,000 employees. This supports the infor-

J. Constr. Eng. Manage., 1997, 123(2): 127-137

mation obtained from previous hypotheses that smaller firms are not as concerned about the impact of international standards on their firms or on their industry.

CONCLUSIONS

Many different conclusions have been drawn from the results obtained from the research investigation and these were discussed in the previous sections after the results were presented. The following is a concise summary of the conclusions.

Conclusions on International Standards

- There is a strong recognition that international safety, as well as environmental and social issues are important issues that will affect U.S. competitiveness.
- In the long term, to ensure global market share, U.S. firms should use international standards.
- Of those surveyed, 100% believe international standards are important, but less than 50% have a strategy for involvement, and less than 50% will sacrifice variety for standardization.
- There is a significant level of lack of understanding regarding the enforcement of international standards.
- Companies do recognize that savings are possible if international standards are used instead of internal standards.
- Most of those surveyed felt they understand international standards, but they only really had knowledge of ISO 9000 standards.
- The standards that currently exist are fragmented and need to be more focused.

Conclusions on ISO 9000 Series of Standards

- ISO 9000 registration costs between $200,000 and $300,000 but this is probably low because it is difficult to account for internal costs.
- The time required for registration averages 15–20 months.
- There is concern that there is no guarantee that countries will honor ISO 9000 registration performed registrars from different countries.
- Other than the propagation of benefits being spread by the promoting ISO 9000 registration, measures that show ISO 9000 has an adequate payback are not available.
- There are certain indicators that ISO 9000 is declining in Europe and companies are questioning the benefits of being ISO 9000 registered.
- The ISO 9000 series of standards may not be good enough since it only represents "doing what you say you are doing."
- Registration to ISO 9000 by third parties is not really third-party registration when companies can select their own registrar.
- There are no strong, cohesive drivers for ISO 9000 registration.
- Very few countries and companies require ISO 9000 registration.

RECOMMENDATIONS

It was not the intention of this study to identify all of the variables associated with the effects of international standards on U.S. construction industry competitiveness. The study was aimed at identifying issues that are likely to affect the nature of construction industry competition related to the development and implementation of international standards. This study is not conclusive in any definitive manner, although it does provide useful information to firms that operate both globally and domestically and who are exposed to the arena of international standards. A number of additional research areas exist that could be pursued to provide more insight into the present and future state of international standards and their effect on the U.S. construction industry. The following are possible ways in which the topic of international standards could continue to be investigated:

- A special effort should be undertaken to work with designers, and members of design firms, to assist them in increasing their awareness of international standards and the impact they could have on the U.S. design industry.
- An effort also needs to be undertaken to provide accurate information to smaller design and construction firms on the potential impact of international standards on U.S. firms, even those who do not perform work in the international arena.
- The first two recommendations could be addressed through special publications, seminars, workshops, or through the efforts of targeted professional societies.
- Special conferences and workshops could be held to discuss the major issues uncovered by this research investigation, such as should the U.S. government take the lead in the area of international standards.
- Monitoring of the development of additional international standards, such as those in the areas of safety, environmental, and social issues, should be done on a centralized basis to keep members of the E&C industry informed of international standards that are currently being developed in these areas.
- A computer program of information on international standards could be developed to provide a centralized source of data and references for those involved with international standards, their development, their implementation, and their use.
- The study could be extended to include more personnel from specific sectors or to concentrate on a specific sector.
- A special task force could be initiated to monitor current and future international standards that impact the E&C industry and to determine the types of standards that will benefit or harm the industry.
- There is a role the U.S. government, in partnership with industry, should play. The construction industry should have a voice in what this role would be in the future.

The importance of these recommendations is realized when the results of this study are examined in light of the participation of firms and individuals from countries in the rest of the world. U.S. participation in the development of international standards, in funding the development of international standards, and the adoption of the international standards is minimal compared to firms and individuals from other countries. If the United States does not continue to be a major presence in the arena for developing international standards, it may be forced to eventually adopt standards that favor firms from other countries or that could prevent them from operating in other countries altogether.

The issues raised in this research project are very serious issues that cannot be ignored and that need to be addressed in the near future for E&C firms in the United States to remain competitive in the global environment. This research project has focused on those issues that will have a long-term impact on E&C firms in the United States, and has tried to demonstrate the importance of not only being aware of what is taking place in the international standards arena, but also encouraging individuals and firms to become more involved: through direct participation in those organizations developing international

standards, through the promotion of organizations that develop international standards, by contributing funds for the development of international standards, through the monitoring of the development of international standards, through cooperative efforts by U.S. firms to influence the development of international standards, and through the development of a mechanism that creates one voice for the U.S. construction industry to protect the interests of U.S. firms.

International standards are a crucial component of U.S. E&C industry competitiveness in the global marketplace. For firms to remain competitive, their members will have to increase their awareness level and become more actively involved in the development and implementation of international standards that will be impacting the firms.

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