GREEN CONSTRUCTION: CONTRACTOR EXPERIENCES, EXPECTATIONS, AND PERCEPTIONS

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ABSTRACT

As the benefits of green building continue to change the Architecture/Engineering/Construction industry and the number of green projects rises in the United States due to market changes, more construction firms are gaining experience with this new way of building and changing their expectations for new hires from degree-granting construction programs. This paper documents a baseline study of contractor experiences, expectations, and perceptions associated with green building conducted in Fall 2006. The study was based on detailed survey results from 87 different companies recruiting from three major university construction programs in the eastern United States (Auburn, Purdue, and Virginia Tech). The survey collected data regarding current experience levels and capabilities of companies with regard to green construction, corporate expectations of new hires in terms of green construction knowledge and skills, and respondent expectations and perceptions about the future of the industry with regard to green projects. The findings of this study support the growing importance of green building as a component of the whole construction market and provide a benchmark against which to measure future changes in the industry over time.

INTRODUCTION

The green building movement is changing the way construction professionals design and build to rethink their approach to almost every aspect of the facility life cycle (Riley et al. 2003; Nobe and Dunbar 2004). According to U.S. Green Building Council (USGBC), green building is a process to design the built environment while considering environmental responsiveness, resource efficiency, and cultural and community sensitivity (USGBC 2006a). A major impetus for the green movement in the United States has been the establishment of green building rating systems such as Leadership in Energy and Environmental Design (LEED) on a national scale and a variety of programs such as the City of Austin Green Building Program and Earthcraft House on local and regional scales, respectively (Tinker & Burt 2003; Tinker & Burt 2004). In addition, the government at federal, state, and local levels and its organizations such as the U.S. Army Corps of Engineers, State of California, the City of Seattle, U.S. General Services Administration (GSA) and others not only require minimum green building standards, but also mandate that future buildings will be green (USGBC 2006a, b; Nobe & Dunbar 2004; DuBose et al. 2007). Furthermore, corporate entities, including Johnson Controls, IBM, Southern California Company, Toyota, and Ford Motor Company, are interested in applying sustainability to their buildings (Kats 2003a, b). Drivers of this change include a desire to reduce the impact of buildings on the environment, to improve working environments for building occupants, to reduce building operation and maintenance costs or simply to project a better public image, among others (Bosch & Pearce 2003; Pearce et al. 2007). Documented benefits from green building practices include energy, water, and other resource savings over the facility life cycle, reduced environmental liability and impact, and even first-cost savings (e.g., USGBC 2006a; Kats 2003a, 2003b, 2004, 2006).

Construction participants have been changing their business structure to respond to the increasing demand for green building among both public institutions and private organizations. According to the U.S. Green Building Council (USGBC), the number of members in this organization grew steadily in the first five years and then expanded rapidly the last 5 years to exceed 7,600 organizations (Figure 1—

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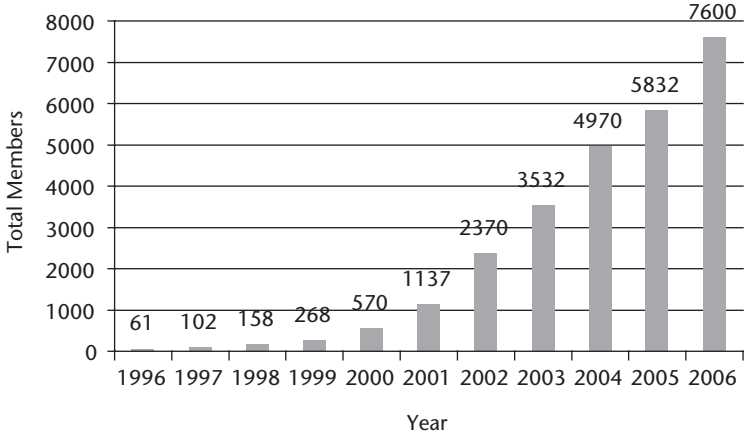

FIGURE 1. USGBC membership growth (USGBC 2006a).

USGBC 2006a). Furthermore, the estimated value of new LEED for New Construction registered projects increased from $0.79 billion to $10 billion (USGBC 2006a), and a recent study by McGraw-Hill predicts more than $59 billion will be spent annually on green building by 2010, up from $10.2 billion in 2004 (McGraw-Hill Construction 2005). There has been a steady increase of LEED projects over the past five years, and USGBC has successfully registered about 750 million square feet of space for potential certification and completely certified about 704 projects (Figure 2) as of the end of 2006 (USGBC 2006a).

The demand for green building has reshaped the design process and changed the role of the contractor (Nobe & Dunbar 2004); led to the development of green building materials (Tinker & Burt 2004); and introduced government regulations and incentives (USGBC 2006a). Furthermore, many professional and trade organizations such as the American Institute of Architects (AIA), Associated General Contractors (AGC), National Association of Home Builders (NAHB), USGBC, American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) and American Society of Civil Engineers (ASCE) have made considerable efforts towards supporting green construction including publishing educational materials, developing guidelines and resources such as the AIA Environmental Resource Guide and ASHRAE GreenGuide (AIA 1996; ASHRAE 2006), creating training programs, hosting green building conferences, contributing to green building rating systems such as LEED, sponsoring of green building research such as ASCE's Practice, Education and Research for Sustainable Infrastructure (PERSI) program, and making national awards for exemplary green buildings (Tinker & Burt 2004; AIA 2006; ASCE 2006; NAHB 2006; AGC 2006; USGBC 2006a). For example, the NAHB has recently published its NAHB Model Green Home Building Guidelines (NAHB 2007); the USGBC continues to evolve new types of LEED-based rating systems that extend to multiple building types and phases of the building lifecycle (USGBC 2006b), and the ASCE has organized a Committee on Sustainability to help promote the principles and practice of sustainability by distributing information on developments and issues that relate to sustainable engineering education and practice (ASCE 2007).

In addition, all construction sectors including residential, commercial, heavy/highway, industrial, and institutional have been associated with this paradigm change not only to increase market share or profit but also to contribute to an environmentally friendly society (Nobe & Dunbar 2004). For example, Turner construction, one of the largest contractors in the U.S., has a steadfast commitment to promote green building efforts to become a leader in green building (Leppert 2004). In addition to promoting green building knowledge, Turner initiated a major green training program for its employees using online tools, encourages its employees to become LEED Accredited Professionals (LEED APs), and has a green building advisory council which is composed of outside industry experts to give them objective advice on best green building practices and drive implementation of those practices (Leppert 2004).

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Growth in green building has brought increased interest in understanding what its short and long term impacts will be. A variety of research efforts have been undertaken to better establish a theoretical basis for sustainability in the built environment as well as to document the costs and benefits of green practices for capital projects. For example, Kats (2003) and Luna and Koman (2006) focused on the costs and financial benefits of green buildings; Arpke and Hutzler (2005) and Ochoa et al. (2005) investigated life-cycle assessment and cost; Okamura et al. (2005), Bunz et al. (2006),Tinker, et al. (2003) and Kibert (2005) concentrated on green building rating systems such as LEED, Austin Green Building Program, and rating systems in other countries; Bosch and Pearce (2003) investigated the array of guidance documents designed to support decision making in public facilities; Nobe and Dunbar (2004) investigated overall sustainable development trends in construction; Pulaski et al. (2006) focused on constructability issues in sustainable buildings; and Beheiry et al. (2006) studied the business impact of owner commitment to sustainability. In addition, many researchers were interested in sustainable construction education. Woodruff (2006), Calder and Clugston (2003), Mead (2001), and Tinker and Burt (2004) investigated approaches to educating engineers, teaching sustainability, construction education, and the green construction curricula. However, to date, comparatively few researchers have reviewed current green building practices in construction organizations such as contractor, architecture, engineering, and consulting firms, their perceptions of the impacts of those practices, or their expectations for green building-related knowledge and skills from new hires from construction programs in the United States.

Objectives

The main objective of this project was to characterize the green building experience and capabilities of construction companies, their expectations for green building knowledge and skills from new hires, mainly graduates, and the future of green building in the built environment from a constructor's perspective. This main objective was achieved by an in-depth survey whose format and content was validated by green building professionals in the construction industry. The survey questionnaire was divided into four subsections to support the main objectives, including: (1) understanding the profile of each company and its specific respondents; (2) examining the current situation of green building in the daily business of each company; (3) examining the importance of sustainability in construction education versus other skills and knowledge required by these companies, and (4) examining expectations and perceptions these companies have about the impact of green building on corporate practice in the future.

Research Scope

This survey questionnaire was restricted in distribution to construction-related companies, including general contractors, subcontractors, and design, engineering, and consulting firms. These companies regularly visit one or more of three sizeable and

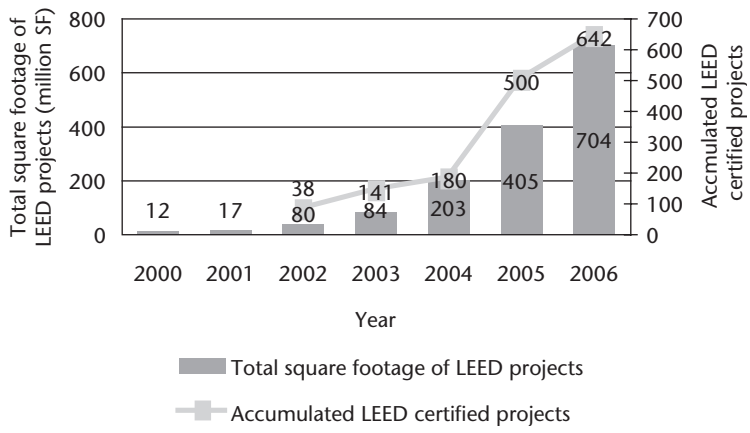

FIGURE 2. LEED project growth (USGBC 2006a).

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FIGURE 3. Location of respondents.

well-known construction programs which are Virginia Tech, Purdue and Auburn University, to recruit students for their internship and permanent positions. Even though the locations of respondents (see Figure 3) are near the three universities mentioned, many of these companies are doing business not just in the U.S., but also all over the world. These companies are also interested in university construction curricula and knowledge of students in the construction program who will become their new employees in the future.

A second assumption regarding the study scope pertains to the assumed relationship between respondent answers and corporate practice and philosophy. In this study, the authors assume that the knowledge of an individual manager is representative of company philosophy and goals, and that respondents' survey answers accurately represent the company by which they are employed.

RESEARCH METHODOLOGY

The overall approach in this study included: (1) selecting sample companies working in the construction industry; (2) developing a survey tool; (3) validating its survey content and format; (4) distributing the survey questionnaire to selected samples; (5) collecting the data from them to measure sustainability in built environment, including each company's sustainability experience and capabilities, the expectation of green building knowledge from their new hires, and the future of sustainability in built environment; and (6) analyzing the colleted data.

Sample selection & distribution

The population being studied here is companies doing business in the construction industry and actively participating a construction career fair at Virginia Tech and Purdue University or visiting the Department of Building Science at Auburn University to recruit new employees and interns as well as to introduce their companies. The survey questionnaire was distributed to 93 companies at the Fall 2006 Construction Career Fair and Interviews at Virginia Tech on October 17, 2006 and to 125 companies at the Building Construction Management Fair Fall Career Fair at Purdue University on October 20, 2006. These companies were mainly general and sub contractors and included several engineering, architecture, and consulting firms. Most questionnaires were collected at the end of the job fair. Several questionnaires were returned to the authors via mail or email after respondents completed the survey at their office.

The Department of Building Science at Auburn University did not have a career job fair during the fall semester 2006. Therefore, the survey questionnaire was emailed to companies visiting the Building Science department to interview students for their internship and full time positions. The placement

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TABLE 1. Survey sample information.

Description	Virginia Tech	Purdue University	Auburn University
Total samples	93	125	36
Refuses	6	23	6
Actual samples	87	102	30

coordinator at the Department of Building Science at Auburn University supplied the list of companies and their contact information.

Table 1 shows the number of instances of survey distribution at the three institutions. There were 254 total potential participants among the three institutions. However, only 219 survey questionnaires were distributed because 35 companies refused the questionnaires. The refuse rate at Purdue University was higher than Virginia Tech because some of these companies had already completed the same questionnaire at the Virginia Tech's job fair earlier that same week.

Survey design and validation

The survey tool was designed in five sections, (1) the company information, (2) the respondent's information, (3) the company's sustainability experience and capabilities, (4) sustainability knowledge expectation from their new hires, and (5) the future of sustainability in the built environment. The survey questions were designed to conform to four basic structures: (1) open-ended, (2) close-ended with ordered choices, (3) close-ended with unordered choices, and (4) partially close-ended.

During a Myers-Lawson School of Construction sustainability panel discussion on October 13, 2006 at Virginia Tech, the survey content and format was reviewed by four sustainability experts from a government agency, a green building architecture firm, a general contractor, and sustainability consulting firm to obtain feedback and to validate questionnaire content and format. After validating the questionnaire content and format by these four professionals, the final survey questionnaire was prepared to distribute to the survey population.

Data Collection and Response Validation

From the population at Virginia Tech and Purdue University, 60 questionnaires were collected at the end of the job fair and 18 questionnaires were received after the job fair via mail or email. The survey questionnaires were distributed to 30 companies at Auburn University, resulting in nine responses by email. In all three universities, two follow-up emails were sent to the population to maximize the response rate. Respondents were motivated to complete the questionnaire by face to face talking during distribution of the questionnaire, the support from three universities, and the cover letter accompanying the questionnaires. From Table 2, the average response rate was approximately 40% across the three sample sets, with Virginia Tech having the highest response rate of 54%. The response rates of Purdue University and Auburn University were close to 30%.

Once completing the data collection, the data was validated through two steps; (1) if only the portion of the questionnaire providing demographic information about the company was completed, these questionnaires were discarded; and (2) if multiple questionnaires were gathered from the same company from the different sample sets, one survey was selected at random for inclusion to represent the company perspective. From the collected data, two identical companies participated in this study at both Virginia Tech and Purdue University's job fair and one company responded to the same questionnaire from the Virginia Tech and Auburn University. After all processing, a total of 87 unique companies were included in the sample.

TABLE 2. Response rates.

	Virginia Tech		Purdue University		Auburn University		Total	
Description	No.	%	No.	%	No.	%	No.	%
Total actual sample	87	100	102	100	30	100	219	100
Response rate from the job fair	35	40.2	25	24.5	NA	NA	60	27.4
Response rate by mail or email	12	13.8	6	5.9	9	30.0	27	12.3
Total response Rate	47	54.0	31	30.0	9	30.0	87	39.7

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ANALYSIS OF SURVEY RESPONSE

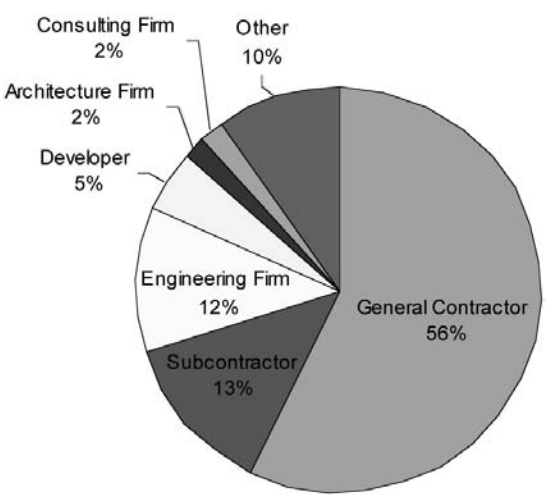
When all data was collected and verified through the research methodology, the data was analyzed. After asking for basic contact information, the first survey question asked about the major business type of respondents. General contractors (Figure 4) represented the major business type at approximately 56%, followed by subcontractors (13%), engineering firms (12%), developers (5%), architecture firms (2%), consulting firms (2%) and others which included manufacturers, suppliers, and government agencies.

To show how representative the sample is across the whole construction industry, the annual business volume and the number of employees of respondents (Figures 5 and 6) ranged from various small general contractors, subcontractors, and consulting firms to mega international contractors with over 10,000 employees and annual volume of $10 billion or more. The major respondent group with respect to the number of employees was the range of 100–500 employees with 32 respondents, and other groups were almost uniformly distributed between 10 to 12 respondents in each category. Companies were more uniformly distributed in terms of annual volume, with most ranges having between 12 and 14 respondents and the range of $100 to $250 million having a few more, 19 in total.

The job title or position of respondents is very important because each respondent represents their company including its structure, mission, and future direction. From the analyzed data (Figure 7), over 50% of respondents were project managers or vice presidents, followed by engineers, presidents, human resource managers, and directors respectively. In Figure 8, 64% of the respondents have completed their bachelor's degree and 29% of the respondents have completed their master or doctoral degree in the areas of business and construction management. From the data, the respondents are well educated in the areas of construction, management, and architecture. Furthermore, the average work experience of respondents is over 15 years in the construction industry or related fields.

The questionnaire asked two questions to measure the level of knowledge of green building of the individual respondent. One question asked whether the respondent was a LEED Accredited Professional, which distinguishes building professionals with the theoretical knowledge and skills to successfully steward the integrated design and LEED certification process (USGBC 2006a, b). The other question was the self assessment of knowledge related to the principles of green building, ranging from no idea to very familiar. As shown in Figures 9 and 10, 15% of the respondents were LEED APs and 79% of the respondents indicated that they were at least familiar with green building. Furthermore, there was a high correlation between the LEED AP and green building familiarity because all LEED APs indicated that they were very familiar or at least familiar with green building.

FIGURE 4. Type of business.



Company Green Building Experience and Capability

The second part of the questionnaire was related to experience and capabilities of the firm itself with green building. The first question was the exposure of the firm to LEED certified and/or green building projects because currently, green building rating systems such as LEED in the commercial and residential sector and regional programs such as Earthcraft that are targeted toward single and multi-family residential are gaining popularity and have been widely used for green building in the U.S. to evaluate the sustainability of built facilities (Mead 2001; Tinker & Burt 2004). The response (Figure 11) indicated that 67% of responding companies already had experience with green building in their business; 6% of respondents had bid or attempted to obtain a green

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FIGURE 5. Number of employees.

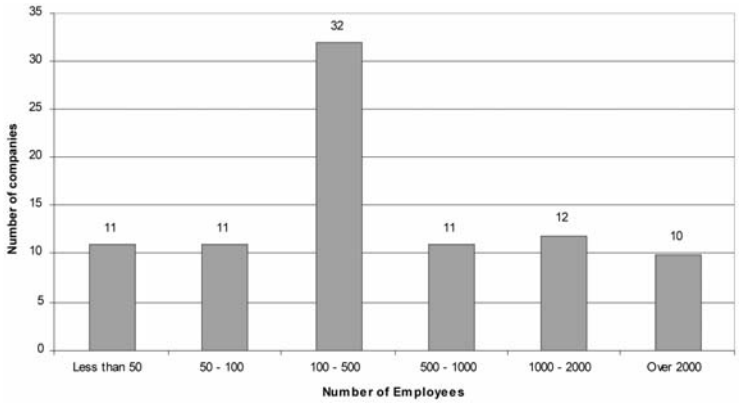

FIGURE 6. Annual volume.

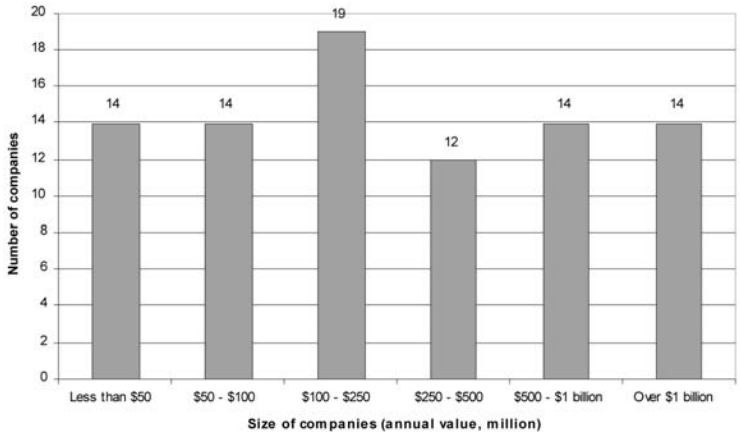

FIGURE 7. Position of respondents.

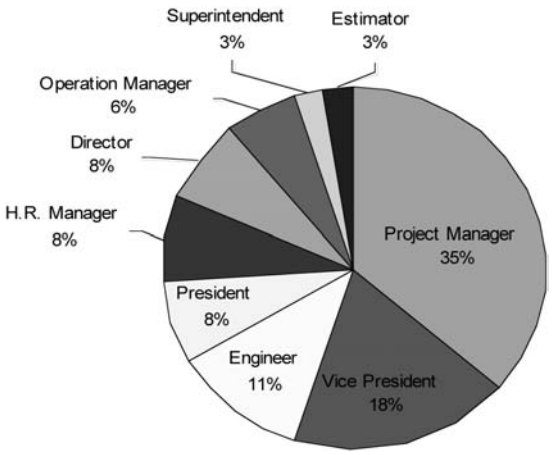

FIGURE 8. Level of education in respondents.

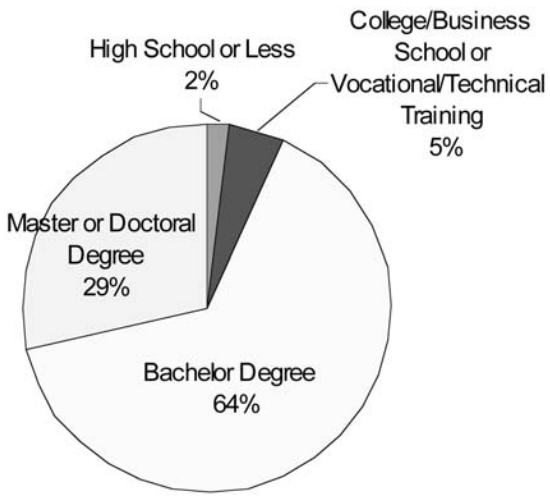

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FIGURE 9. Presence of LEED AP.

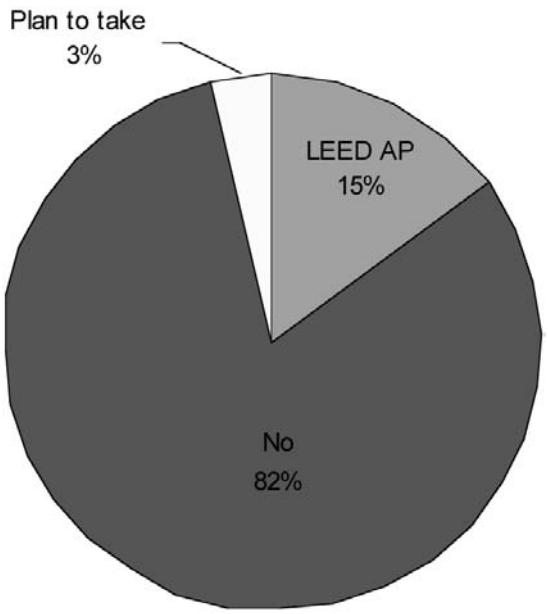
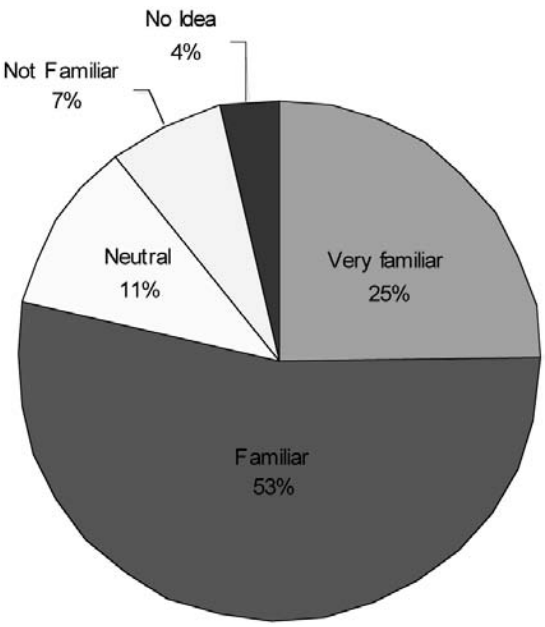


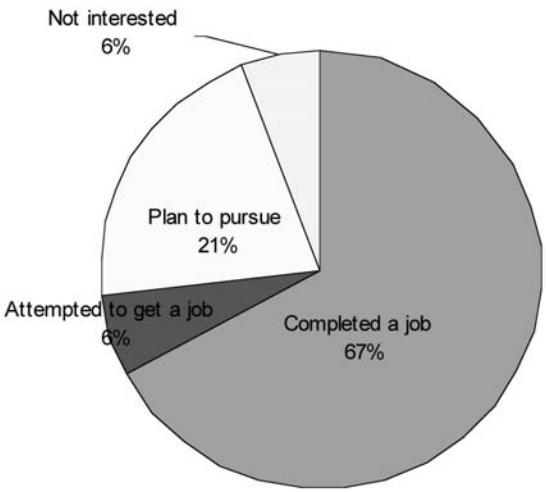
FIGURE 10. Familiarity with green building.



building project but were not awarded the project; and 21% of the respondents planned to get into the green building market in the future. Only 6% of the respondents replied that they were not interested in the area of green building.

The next question focused on the types of green building projects completed by the respondent's company. Respondents could pick multiple project types if their company had experience with green building projects in different sectors. The response (Figure 12) indicated that commercial and governmental sectors (32% and 18%) were a leading market segment for green building compared to retail and religious sectors (4% and 2%). Some possible reasons are that institutional owners consider green building to minimize operating and maintenance costs, to decrease employee absenteeism, to increase employee productivity, satisfaction, health, and retention and to provide comfortable office spaces to their employees (Bosch & Pearce 2003; Kibert 2005; USGBC 2006a). In addition, many federal or state governments and their agencies such as GSA, Army, Navy, etc. have already established green building requirements for their new construction through formal or informal policy (USGBC 2006a). The proportions of

FIGURE 11. Exposure to green building projects.



project types are very similar to the distribution of LEED certified building types (USGBC 2006a).

Figure 13 shows how responding companies obtain green building knowledge and skills to support green building projects and initiatives. The question was composed as a closed-end question with multiple

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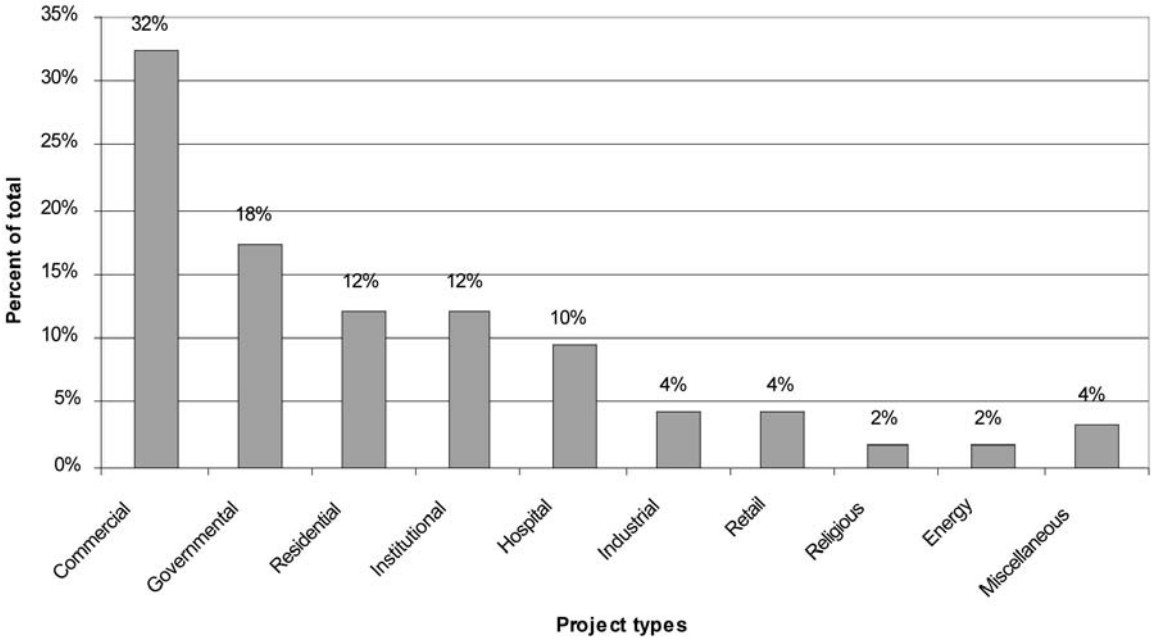
FIGURE 12. Types of completed green building projects.



choices from which the respondents could pick the best answer or answers from among all the possible options. An "other" option was also included to provide a means for identifying other ways of obtaining green building knowledge and skills. The response indicated that sending employees to sustainability related conferences and reading green building trade publications were the most widespread ways for companies to get green building knowledge and skills. Other widely used strategies for finding necessary knowledge and skills were doing internal research and hiring a green building consultant. Other ways to get green building knowledge included hiring an architect who was knowledgeable in the areas of green building, visiting LEED certified buildings, and actively using the resources in the USGBC.

The next questions targeted green building policy or guidelines and construction training programs. Eleven respondents mentioned that they had a green building policy or guideline in their company to guide the company's decisions and actions for their green building projects or programs. Seventeen respondents indicated that their company had a green building training program to improve green building knowledge and skills, to identify key practices of green building, to establish competencies in applying LEED and other relevant criteria or established guidelines, to take advantage of financial incentives and technical assistance offered by government, utilities and non-profit organizations, and to work with architects, designers, building operators, and utilities

FIGURE 13. Sources of green building knowledge in responding companies.

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to improve building performance. The average number of training hours on green building topics was about 13 hours, and programs were prepared and administered by either internal or external green building professionals.

Twelve respondents indicated that their company currently has a green building division or a green team to pursue and manage green building projects of various sizes (Figure 14). The size of the team and division varied from a small team or division (1 to 5) to a sizable team or division (over 15), and project managers and executive members were mainly involved in the green building team or division. Of the 75 companies which did not currently have a green building team or division, 36% of the respondents indicated that they will consider creating a green building team or division, 52% of respondents indicated that they would consider creating one depending on the market situation, and only 12% of the respondents had no interest in forming a green building team or division (Figure 15).

From the analyzed data, 51% of the respondents indicated that their company had at least one LEED AP and four general contractors already have over fifty. Forty companies offered incentives to motive their employees to become a LEED AP (Figure 16). The most widely used incentive is that the company supports the cost of the LEED AP exam and sends their employees to green building training programs. Furthermore, four companies indicated that employees passing their LEED AP exam would receive salary increases, and three companies offer an incentive of promotion to employees passing the exam.

Corporate Expectations of New Hires

The growth and importance of green building increases the need for construction managers, architects, and engineers with knowledge in the various aspects of green building (Tinker & Burt 2004). Furthermore, construction-related companies also absorb green building knowledge and techniques from incoming employees such as university graduates. Based on green building knowledge expectations companies may have for new hires, construction educators need to incorporate sustainability into courses and curricula so that graduates can participate and be valued in the workplace, as well as expand traditional means and methods of construction to the new construction paradigm

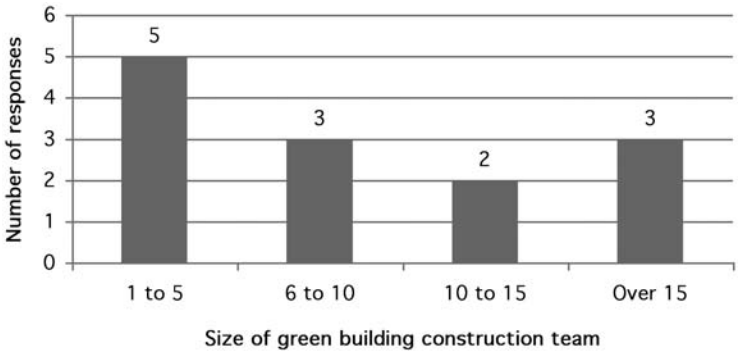

FIGURE 14. Size of sustainable construction team.

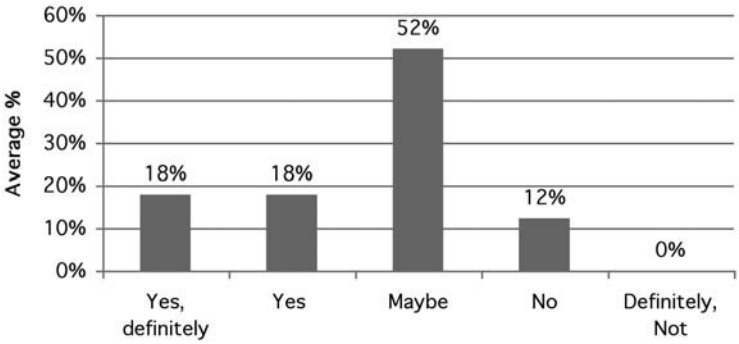

FIGURE 15. Willingness to create a green building division.

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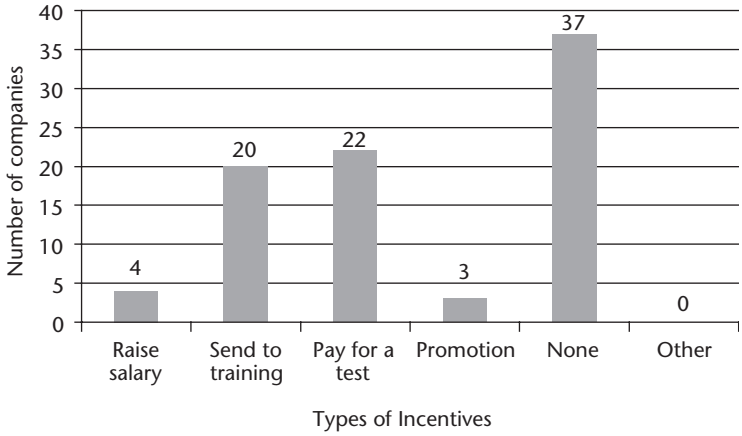
FIGURE 16. Types of incentives.



which creates an environmentally responsible, healthy, and prosperous environment.

65% of survey respondents indicated that they expect graduates to have some knowledge of green building. Primarily, they anticipate basic knowledge and concepts of green building, green building rating systems, especially the LEED rating system, life cycle costs of green building, the green building design process, and familiarity with green building in general. 35% of respondents do not expect any knowledge of green building from graduates being hired by their firm.

The next question asked what specific green building skills and knowledge construction-related programs in university need to teach students. 35 respondents suggested topics that are important to include as part of university curricula, included in Table 3. Nineteen respondents specifically emphasized the importance of knowledge on sustainability rating systems, especially LEED. Ten respondents requested general

TABLE 3. Requested green building knowledge from respondents

Content of sustainability in education	Number of Respondent
General knowledge of sustainability in built environment Green building familiarity Basic green knowledge A general knowledge of the process In-depth instruction with principles and design application	10
Rating system and design of sustainability LEED requirements LEED certification course Economic feasibility for LEED LEED process and design Exposure to LEED Accredited LEED students	19
Sustainable construction material and methods Construction material and sustainable methods of construction alternative energy Coordination of sustainable efforts with all parties design phase HVAC items Practical and applicable green building construction techniques and products. Practical system for buildings that saved energy study ASHRAE 90.1	5
Others Environmental philosophy	1

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TABLE 4. Importance of knowledge and skills for graduates

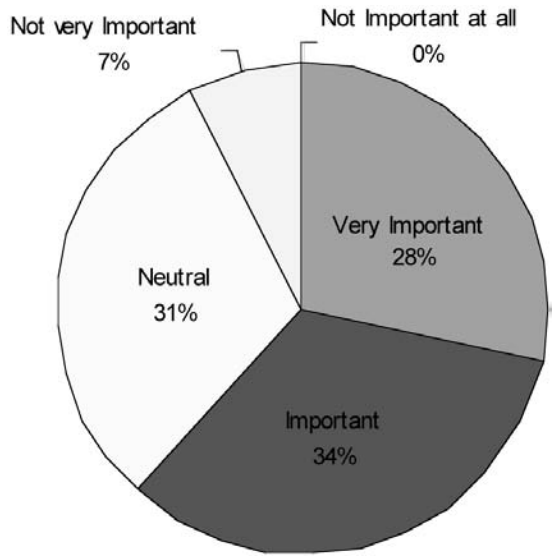
Knowledge/Skills	Virginia Tech	Purdue University	Auburn University	Average
Ethics	4.7	4.46	5.00	4.7
Problem Solving	4.7	4.62	4.57	4.6
Critical Thinking	4.5	4.42	4.57	4.5
Teaming	4.3	4.32	4.57	4.4
Practical Skills	4.4	4.23	4.43	4.4
Leadership	4.4	4.40	4.25	4.4
Adaptability	4.3	4.08	4.43	4.3
Technical Skills	4.1	3.85	4.29	4.1
Writing Skills	4.1	3.81	4.29	4.1
Public Speaking	4.0	4.08	3.75	4.0
Managerial Skills	4.0	4.04	3.86	4.0
Safety Understanding	4.1	3.88	3.86	3.9
Project Delivery System	3.6	3.61	4.14	3.8
Followership	3.1	3.42	3.25	3.2
Sustainable Knowledge	2.2	2.38	2.25	2.3

knowledge of sustainability in the built environment so students can be familiar with green building concepts and issues.

The next question dealt with what construction-related companies expect from recent construction graduates. The basic format of the question and the list of skills and knowledge in this question was adopted and extended from previous studies conducted by Sounder and Gier (2006), Mead (1999), and Beliveau and Peter (2004). The response (Table 4) indicated the importance of construction knowledge and skills for new hires from construction-related programs using a 1 to 5 scale (1 = not important and 5 = very important). Construction companies continue to recognize that ethics, problem solving, and critical thinking are the most valuable and important skills from their new hires who complete construction related degree programs in the U.S. The knowledge and skills rated lowest by respondents to this survey are the knowledge of green building, followership, and the concept of project delivery systems.

The next question involved the importance of teaching knowledge of sustainability and environment in construction programs. 28% of all respondents believe that the teaching the knowledge of sustainability and environment is very important as a part of construction curriculum. 33% consider it important, while 7% of the respondents believe that construction programs do not need to teach knowledge of sustainability and environment as a part of the curriculum in the future. This response provides a different perspective to the answers to the previous question illustrated in Table 4, which focused more on the relative importance of all skills and topics covered in the construction curriculum. While this study did not provide a means to further explore this apparent contradiction, the results suggest a need for further investigation to better understand the reasoning behind this potential discrepancy.

FIGURE 17. Importance of teaching green building.



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Future of green building

Many organizations such as governments, professional associations, contractors, etc. believe that green building will dominate the way people build in the future and reshape the industry. 62% of respondents answered the free response question "How will green building impact the construction industry in the future?". The answers were clustered into three basic categories along with a miscellaneous category based on the sentence meaning. Table 5 lists examples of typical answers. Five respondents to this question indicated that they believe green building will not be important in the future.

Green building has often been perceived to be more expensive than conventional buildings and often considered not worth the extra cost. However, in one study, the average premium from 33 green buildings (Table 6) across the U.S. compared to conventional designs for those same buildings was slightly less than 2%, or \$3–5/ft^2 because of increased architectural and engineering design time, modeling costs and time necessary to integrate green building into projects (Kats 2003a).

Other studies have found a range of results ranging from an average of less than 1% cost premium for projects at the lowest level of certification to 7% or more for buildings at the higher levels of certification (e.g., Kats 2004; SWA 2004; Kats 2006; Nilson 2005).

To better understand the perceived green building premium by the construction industry, the next question asked what level of cost premium respondents believed green buildings would carry compared to conventional construction. 35% of respondents believed that the cost premium of green building is about 5% to 10% compared to conventional construction, and another 27% of the respondents believed the cost premium would be greater than 10%. 38% of the respondents indicated a belief that green building costs between 0–5% more than conventional construction. These responses demonstrate that the construction industry still believes that green building costs significantly more than conventional construction, despite the growing body of evidence to the contrary.

The next open response question was to ask respondents about ways to minimize the premium cost

TABLE 5. Impacts of green building on the future of construction (typical responses).

Content of future sustainable construction	Number of Respondents
Sustainable construction will be very important or standard construction in the future. It will be dominant. It will change the way of constructing a building. I will become important part in the future. It will reshape the industry. It will become increasingly cost effective, thereby increasing its application. The institutional & government construction is heading forwards. Many organizations now require a LEED certification.	45
Sustainable construction will evolve some degree of construction. A construction project will be implemented in some degree of construction. The future of sustainable construction depends on government regulation and incentives.	2
Sustainable construction is not much in the future. It will increase cost without understanding of customary return of investment. It may make price unattainable. It will increase the cost of construction and decrease percentage of approval on early submissions by local jurisdictions. It will affect the lowest amount in the future. It will not be much in the next 10 years.	5
Others Reduction in waste as the environment becomes a main focus. It will substantially reduce the country's dependence on natural resources.	2

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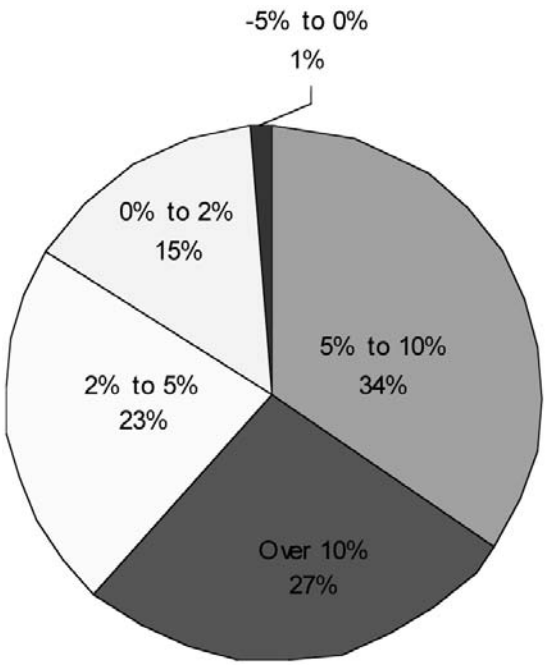
TABLE 6. Level of green standard and average green cost premium.

Level of Green Standard	Average Green Cost Premium	Number of Study
Level 1—Certified	0.66%	8
Level 2—Silver	2.11%	18
Level 3—Gold	1.82%	6
Level 4—Platinum	6.50%	1
Average of 33 Buildings	1.84%	Total : 33 studies

Source: USGBC, Capital E Analysis (Kats 2003a)

FIGURE 18. Cost premium of green building with respect to conventional construction.



of green building. Many respondents believe that the construction industry needs to take action (Table 7) to minimize the premium cost of green building in the future.

16 respondents indicated that the way of minimizing the cost premium was to increase the size of market and owner's demand, so that green building might be a general practice in the construction market. 14 respondents suggested that the construction industry has to minimize the cost of green building materials and to improve their availability in the market. There were other recommendations suggested as well, which included educating owners to understand the life cycle benefits in the long term, minimizing administrative burdens, increasing government incentives, and teaching knowledge of green building to employees.

SUMMARY AND CONCLUSIONS

Several conclusions can be drawn from the analysis completed in this research. First, the green building movement is changing the construction industry and the green building market is growing into a significant share of the total construction market. Furthermore, a significant share of construction stakeholders surveyed, including contractors, and architecture, engineering, and consulting firms have knowledge of or actively participate in green building projects and practices.

Second, 67% of respondents experienced green building projects in their business, of which the main types of completed green building project were commercial and governmental buildings. A primary driver for green building discussed in the literature is that corporate and governmental owners consider green building to minimize operating and maintenance costs, to decrease employ absenteeism, to increase employee productivity, satisfaction, and health, and to provide comfortable office spaces to their employees.

Third, the construction-related industry obtains green building knowledge and skills from sending their employees to sustainability related conferences and reading green building trade publications, which are the most widespread ways to get green knowledge and skills among survey respondents. In addition, many companies offered several incentives to motivate their employees to become LEED APs. The most widely used incentive is that the companies support the cost of the LEED AP exam and send their employees to green building training programs.

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TABLE 7. Reducing the cost premium for green building—typical responses

Premium cost of sustainable construction	Number of Respondents
Common practice of construction and design Improve design approach More common practice which will create creative and efficient methods of construction Increasing demand for green building Mainstream in the construction industry Lack of companies of products and the need to develop more cost effective solution	16
Sustainable material Encourage manufacturers to provide environmentally friendly products with low cost High material costs More material products in the market Salvage for resale Cost effective manner for finding reuse materials Material purchasing possibility	14
Owners aware of potential saving—Life Cycle Cost Overall energy saving Comparison between upfront cost and operating and maintenance cost Life cycle cost of building system Life cycle cost return Most cost effective life cycle cost	8
Administrative burden Minimize the paperwork Too much documentation Simplicity Less administrative burden	4
Government incentives Tax incentives and low permit fees Lobby for government incentives	3

Fourth, 65% of respondents expect green building skills and knowledge including basic knowledge and concepts of green building, green building rating system, life-cycle cost of green building, green building design process, and familiarity of green building from their new employees, especially graduates from construction-related programs. Furthermore, the construction industry would like universities to teach green building rating systems (e.g., LEED), general knowledge of sustainability in the built environment, and green building materials and methods to students who study construction so they can be familiar with green building. Despite these findings, this study also found that construction companies surveyed rate ethics, problem solving, and critical thinking as the most valuable and important skills from their new hires who complete construction-related degree programs in the U.S., with green building rating as the least important skill among the larger set of general construction skills typically taught by university programs. This finding presents a contrast with responses indicating the importance of green building knowledge and skills in new hires. Multiple explanations may underlie this apparent contradiction and pose a rich area for additional research.

Fifth, construction-related companies believe that green construction will be very important or standard practice in the future even though they still believe that the initial cost premium is very high compared to conventional construction. The respondents recommend that green construction has to be a common practice, material manufacturers have to minimize the

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cost of green building materials, and owners must be aware of potential savings from a life cycle perspective. Furthermore, rating organizations should minimize administrative burdens and governments should offer several incentives to promote green construction.

FUTURE RESEARCH

This study has provided an important snapshot of the current status of the construction industry in the U.S. It focused on obtaining a better understanding of current beliefs among construction companies about green building, current resources and practices of those companies, and current expectations companies have of university graduates who enter their employment. The study tapped a strong pool of respondents who interview at universities with leading construction programs, and it represents the perspectives of a broad diversity of construction firms.

Future research will include replicating and expanding this study over time using similar methods to evaluate how industry beliefs change and evolve over time. With green building receiving growing awareness in each of these three universities and institutions of higher learning around the U.S., this study provides an initial baseline to understand how corporate expectations and beliefs may change as a result of influences including the hiring of new graduates with greater green building knowledge. A companion study is presently under development to evaluate universities' understanding of industry expectations for their graduates regarding green building skills and knowledge. Together, these studies will provide an ongoing means for more effective diffusion of sustainability concepts into the construction industry.

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