Sustainable Best Practices and Technologies

A Report on the Current Status of the Construction Industry

Zack Winters

ZACK WINTERS
PROJECT AND REPORT
4/29/09

Table of Contents

Executive Summary

The Architecture/Engineering/Construction (AEC) industry is constantly changing - presenting new opportunities for some involved and closing doors for others. As these opportunities are presented, they create advancements in technologies that expand our current grasp of the industry and how we construct projects. Given the vast strides that the AEC industry has taken in the last decade alone, certain technologies and best practices have become increasingly common. This study aims at evaluating a new way to approach data collection and providing an estimation of the current industry status, how it is progressing, and why certain innovations are being embraced.

To facilitate this goal, the study presented companies associated with Virginia Polytechnic and State University with five protocols that addressed company demographics, current sustainable practices, and possible future practices that could be employed by the company. Summer interns, inside the participating companies, administered these protocols providing a new perspective and method for gathering the requested information.

Upon analysis of the results, industry participants, primarily mid- to upper management, reported themselves as highly innovative (70% reported sevens and eights on a ten point scale) and their companies as 65% innovative (reporting mostly eights, nines and tens on a ten point scale). Additionally, of the companies reported, 91% were tolerant of new ideas. To support this information, the study reported that the primary investment was distributed to project specific innovations (52%) and employee training (41%), citing the most common certification as LEED accreditation and PE licensure. This data supports a perception that the industry is embracing new technologies and adapting to a changing focus in the economy and construction industry.

Among these new technologies that the industry is embracing are sustainable innovative practices and technologies. The increase in requiring these practices and technologies among both government and public sectors has created a larger demand than has been present in past decades. However, to fully understand where the industry is heading, a current benchmark should be established. This snapshot of the industry may not only provide valuable information to companies on where they stand compared to their

competition, but may provide insight into why certain products are being adopted. In an attempt to address these issues, this study reports that of the practices investigated by the research team, 89% of company respondents had prior knowledge of the practice. At the same time, when asked their company's opinion of support for the practice, 51% reported that they felt their company would be against the practice, thereby reinforcing the status quo where the practice in question is not used. Furthermore, of the practices reportedly in use by the companies, 40% were instituted to achieve cost savings. Additionally, of the total companies surveyed, 29% of practices and technologies were reportedly used for no other reason besides cost savings.

Given the data presented in this report, it is possible to begin to understand which companies are using sustainable innovations, which practices and technologies they are using and why they may be using them. This data not only helps the individual companies that are adopting the innovations, but also the industry as a whole, conclude where it is and in which direction the AEC industry is headed.

Introduction

The AEC industry employs over 7 million workers and produces around 1.3 trillion dollars in work per year, comprising more than 10% of the GNP (Crew 2006). This level of work requires collaboration among all parties involved and requires the participants to make complex decisions (Pacey 1992). The complexity of these decisions incorporates numerous factors into the decision making process. These factors revolve around the most efficient and innovative processes and products from economic and organizational perspectives. Similarly, these decisions are also based on previous performance outcomes and perceptions of the products implemented. Overall, they are directly related to the goals of the specific project and abilities of the contractors involved. There are additional factors, however, that can contribute the decision to adopt an innovative product.

The construction industry relies heavily on the performance of the people involved on all stages and levels. The process is constantly changing and the effects of these changes are widespread and rarely isolated. The emergence of these changes in construction technologies and best practices can assist the contractor in the development of an efficient project and a successful business. Moreover, as innovative projects emerge and are presented to the industry, their implementation can help preserve resources and improve the impacts of the industry on the natural environment by reusing waste and controlling the use of non-renewable resources (Kates et al. 2001). Essential to this process are the decisions that are continually made by contractors to adopt these practices and technologies or to opt to use traditional versions. Developing products that reduce energy consumption or utilize waste products represent a movement towards a symbiotic relationship between demand for resources and supply of resources (Kates et al. 2001). However, the development of these practices and technologies is only the initial step.

The continual progression of innovative best practices and technologies requires their continual adoption amongst those seeking to remain competitive in the AEC industry. This continual adoption must be consistent with the current social system in order to produce a high rate of adoption among members of the industry (Rogers 2003). Sustainable practices and technologies are considered to be a large concern of the

current social system; however, benchmarks must be established to fully understand where the industry is heading.

Background

The decision-making process of innovation adoption in the construction industry is complex and contains unique factors that contribute to uncertainty. Previous research suggests that the decisions of firms to adopt innovations can be influenced specifically by uncertainty surrounding products' multiple attributes (Toole 1998; Rogers 2003). The complexity of innovation adoption theory therefore requires a synthesis of major attributes (risk) into two distinct areas offering competitive advantage through a reduction of complexity: 1) relative advantage through process improvement and 2) organizational advantage through supporting environments (Toole 1998; Rogers 2003). A firm's technological process creates relative advantage in opportunities for process improvement. A firm's ability to reduce the influence of outside factors limit decisions of whether or not to adopt a given product creates organizational advantage. Further, decision-modeling studies correlate uncertainty in adoption to effects from the absence of performance data on given product innovations (Toole, 1998; Slater and Mohr, 2006).

Toole suggests that successful adoption of an innovative product can be traced to four construction-specific factors including: location, means of production, materials, and incorporation of system design (Toole 2001). As each product moves along the trajectory it is exposed to outside factors. Toole argues that previous performance is one of the primary factors in the decision to adopt an innovation (ibid.). The installed performance of a product, as opposed to its construction or design performance, is highly valued by the contractor (ibid.). The reduction in the variability of performance of a product implies higher customer satisfaction and reduces the need for further attention to the product from the contractor (ibid.). This suggests competitive advantage through process improvement of an innovation and the value it has to the contractor as a reinforcing factor in their decision process.

This general understanding of competitive advantage and why a company may choose to adopt an innovation is essential to producing a high rate of adoption. As McCoy et al. (2007) report, "Getting an innovation into the market requires more than just developing something that works. The technical development, or *invention*, must be matched to an appropriately synchronized, increasingly sophisticated assessment of both the potential

market and the channels through which the product may reach it." Moreover, to complete the notion that organizational best practice results from supporting environments, including markets or social systems, this report focuses primarily on sustainable practices and technologies in response to their growing presence in the AEC industry in the United States.

Sustainable practices and technologies have entered the forefront of the construction industry. Since 2001, membership in the U.S. Green Building Council (USGBC) has grown from 1137 members to over 7600 members in 2006 and has continued to rise (Ahn and Pearce 2007; 2009). Additionally, as the number of USGBC members increases, more public and private corporations are moving toward LEED certified buildings as part of their objectives for new building projects. The federal, state, and local governments and related organizations, including the U.S. Army Corps of Engineers (USACE) and the U.S. General Services Administration (GSA) are beginning to make green building standards mandatory (ibid.; Keysar & Pearce 2007; Pearce et al. 2007; DuBose et al. 2007). In the public sector, IBM, Toyota and Ford Motor Company are also becoming more engaged in LEED design and green building principles (Ahn & Pearce 2007). To aid in these organizations in their pursuit of sustainable innovative practices, a field guide was developed to help ensure their proper use (Field Guide for Sustainable Construction, 2004). This guide outlines the following categories for sustainable innovative practices and technologies:

- Procurement
- Site/Environment
- Material Selection
- Waste Prevention
- Recycling
- Energy
- Building and Material Reuse
- Construction Technologies
- Health and Safety
- Indoor Environmental Quality

As these government and public entities begin to move toward adopting sustainable

practices and technologies as part of their objectives for capital projects, other organizations may begin to follow suit. Fostering this growth will require continual monitoring. The establishment of a baseline for the current status of sustainable innovations may prove helpful in not only understanding which companies are using which practices and technologies, but also why they are choosing to use them.

Research Objectives and Limitations

The focus of this report is to identify the current state of the industry and provide a glimpse into why companies are choosing to adopt sustainable innovative practices. The following study reports the results from five data collection protocols. The companies involved in the study represent a cross section of the construction industry and specifically were selected because they hired Virginia Tech students as summer interns who were participating in BC 5974: Internship for Credit. The companies have been kept anonymous to protect the interests of both the companies and the University. It should be noted that given the variety of the companies involved in the survey, each result should be compared against the base demographic and each sustainability practice should be compared to the company as well. The companies represented vary from large, billion dollar per year revenue companies to small landscape subcontractors and everything in between. Sustainability best practices investigated in the study range from paper recycling to reusable concrete forms. The materials, manpower and effectiveness of each practice inhibit an accurate comparison against each other and lend to a comparison against how an average company would employ and utilize a given practice.

Methodology

In an attempt to advance the curriculum offered by the Virginia Tech University, the methods of establishing this benchmarking survey relied upon data collected from interns of the Virginia Tech University Building Construction Department. This innovative data collection method stems from a desire to move student learning objectives from an "investigative" approach to an "interpretive" one (Pearce & Fiori 2009). In other words, the idea is to have students directly engaged in the learning process and interpreting data based on the context of the situations with which they are presented as opposed to traditional learning in the classroom.

This survey established five protocols for the interns to administer to the companies in which they were employed. These five protocols were individually focused on issues pertaining to the adoption of innovative sustainable practices and technologies, but remained applicable to the wide variety of contractors that were participants in this survey.

Prior to the beginning of the summer, the students were briefed on the proper way to conduct these surveys and provided with instructions on how to report the data. The companies involved in the survey were also informed of the procedure for the survey and advised on what to expect from the students. Across the course of the summer, the students were distributed the protocols via a Blackboard site, in two-week increments. After students had completed each survey with their respective corporate participants, the data was entered into an online survey mechanism that automatically compiled it.

In addition to the completion of the on-line surveys, the students were required to provide feedback through comments and discussion board participation on how they felt the process was working. This process was facilitated and compiled through a Blackboard Site. This process of presenting feedback to the faculty was to affirm or negate the how this pilot process worked. Given this method of data collection is new to the Building Construction Dept., the lessons learned section was extremely important in the development of this innovative methodology.

Protocol 1 – Internship Information

The first protocol dealt with understanding more about the student, the company they planned to work for, and the job that they were undertaking throughout the summer. This protocol was completed prior to the beginning of the internship, so some of the questions required the students to contact their employers to learn more about the company and their job.

Students were asked questions relating to their prior work experience, level of education, and their concepts and understanding of sustainability and green building. Other questions focused upon the type of construction work the company they were working for participated in and the environment in which they planned to be working that summer. Additionally, students were asked to provide the name and contact information of their supervisors so that faculty could contact them if needed.

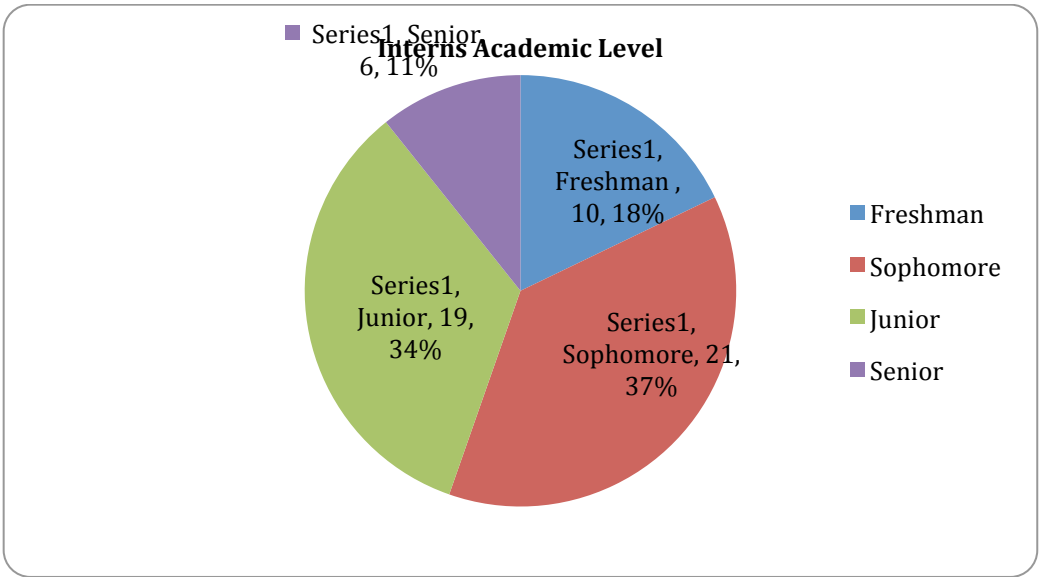
The purpose of the first protocol was to establish a snapshot of the students. This protocol established the foundations for other protocol questions.

Protocol 1 – Internship Information Results

The following answers for Protocol #1 represent the demographics of the student interns in charge of collecting data. Additionally this Protocol addresses some basic company information and, more specifically, the individual representative from the company involved in subsequent surveys. Certain data were omitted from this report to maintain confidentiality. Additionally, some answers were modified to expedite the sorting process. These answers are noted in the report below.

About You

- What year are you in your studies?
    - The results of the study show a breakdown as follows:
        - Freshman – 10
        - Sophomore – 21
        - Junior – 19
        - Senior – 6



- What is your major?
  - Question was not answered or present in results, since all participating students were from the Building Construction Department.

- Please describe your prior work experience in the construction industry. Include company name, duration of your employment with each company, and a description of the work you did with that company. If you have informal experience with construction, please describe that too.
  - **Internship** – (50) students reported having prior internships. These answers were grouped based on the notion of an internship having some experience with a construction industry company.
  - **Self-Employed** – (1) student reported being previously self-employed in the construction industry.
  - **None** – (4) students reported having had no previous experience inside the construction industry.

- Define what do you think sustainability means with respect to the construction industry.
  - Typical answers included:
    - "Sustainability in the construction field means that the building will serve the needs of the people who use it without harming the future generations who might use it. Sustainability is necessary from the start of construction throughout the life of a building. An example of a sustainable practice would be using low energy mechanical systems, or planning for uses for storm water runoff."
    - "Sustainability in the construction industry is the use of construction practices and materials that are friendly to the environment in the present and for future generations."
  - Atypical answers included:
    - "To me, sustainability means completing its designed life-span with minimal maintenance needs."

        - "To me, sustainability means that there will always be a need for construction. The industry will be sustained by the need to renovate and fix up old construction, as well as the growing need for new construction."
- Please describe any experience you have with sustainability or green building. Include formal activities associated with school or job, or any other experience you have that might be relevant.
    - **Academic** – (28) students reported having learned about sustainable practices in an academic setting, whether VT or other classroom settings.
    - **Outside Experiences** – (7) students reported having been exposed to sustainable practices through settings other than academic. These are mostly related to family and friends who are in a "green" industry.
    - **None** – (19) students reported not having any experience with sustainable practices.

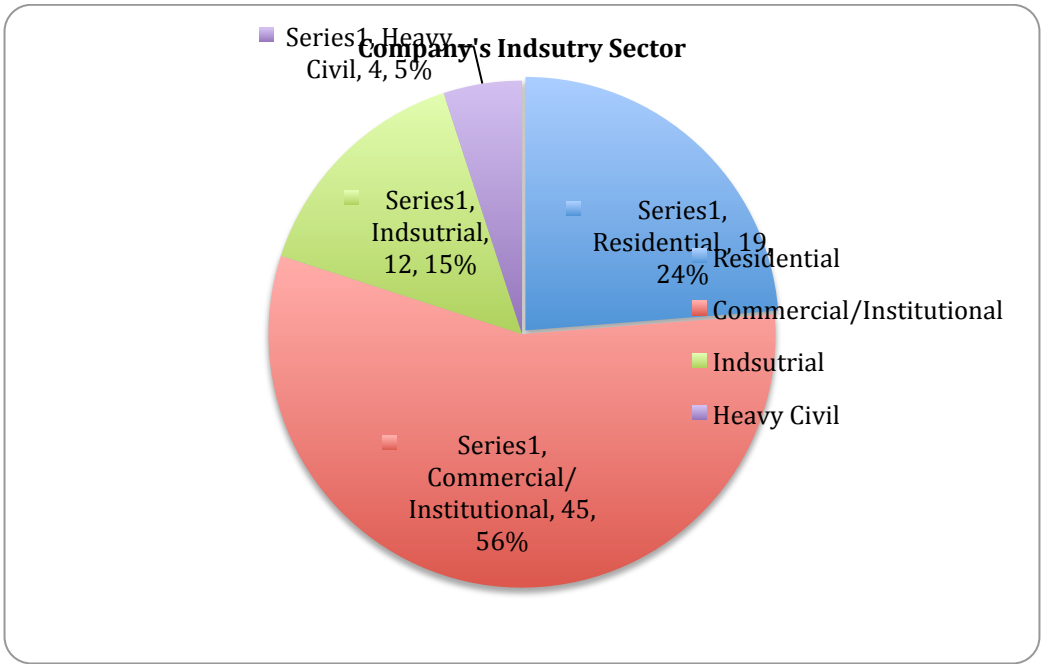
- Please specify your gender and race (Optional) .
    - Male – (51)
    - Female – (4)
    - Caucasian – (39)
    - Hispanic – (2)

About Your Company

- **What is the name of the company for which you are working this summer?**
    - Avalon Bay Communities
    - Balzer and Associates
    - Bovis Lend Lease
    - Brasfeild and Gorrie
    - Brisk Waterproofing
    - Centennial Contractors
    - Donley's LLC
    - Gilbane Construction
    - Grunley Construction
    - Hatchett Home Improvement
    - Heartwood Corporation
    - Helix Constructors LLC
    - Hourigan Construction Co,
    - James G. Davis Construction Corporation
    - JM Olson
    - JPL Properties
    - Kjellstrom and Lee
    - Lobar, Inc.
    - Marquis Custom Homes
    - MEB General Contractors
    - National Pools of Roanoke, Inc.
    - NVR (Ryan Homes)
    - Quality Construction
    - R.W. Murray Co.
    - Scott-Long Construction
    - Skanska

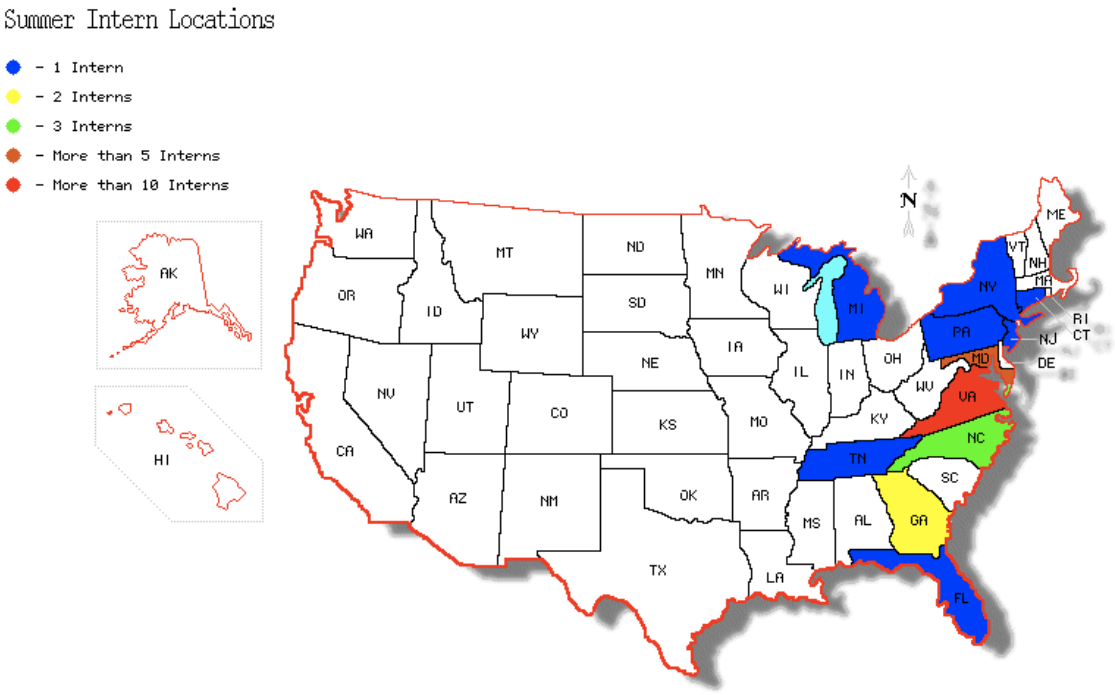
- Stanley Shield Construction
- Truland
- Turner Construction Co.
- TWCC
- Virtexco
- W.M. Jordan Company
- Waterman Excavation
- Whiting – Turner.

- **What sector of the industry does this company target?**
  - **Residential** – (19) students
  - **Commercial/Institutional** – (45) students
  - **Industrial** – (12) students
  - **Heavy/Civil** – (4) students reported their company works in this field.
  - **NOTE**: results were combined to show the four distinct fields of industry. Some results were reported for a company working in multiple fields (i.e. commercial and residential). In this situation, the answers reported were counted twice.



- **Where will you be working this summer? Please provide city and state.**
  - North Carolina - 3
  - Virginia - 32
  - Washington, D.C. - 3
  - Maryland - 7
  - Georgia - 2
  - Pennsylvania - 1
  - Tennessee - 1
  - New York - 1
  - Connecticut - 1
  - Florida - 1
  - New Jersey - 1

- Michigan - 1



About Your Job

- **What, if any, experience do you already have with this company? Describe your existing level of knowledge of and/or experience with the company with which you are working this summer.**
  - **None**: (33) students reported they have not prior experience with this company.
  - **Prior Experience**: (19) students reported they had prior experience with this company.
  - **NOTE**: Answers for this question were interpreted for ease of analysis. Answers were not limited to "Yes" and "No".

- **Who will be your direct supervisor during the summer? Please provide name, job title, and contact information.**
  - Results were omitted to maintain anonymity except for position. The results are as follows:
    - Superintendant - 8
    - Project Manager - 12
    - Senior Project Manager - 3
    - Vice President - 7
    - Owner - 4
    - Project Engineer - 1
    - Estimator - 1
    - Other – 3

  NOTE: Answers for this question were interpreted for ease of analysis. Answers were not limited to the specific choices listed above (i.e. "Superintendent" may have been listed as "Field Superintendent")

- **What is the period of your employment this summer? Please provide anticipated start and end dates.**
    - The summer internships were most commonly reported as starting the month of May and ending in the month of August.
- **What is your expected work schedule? For instance, what hours will you be working? What days of the week?**
    - The average work schedule was reported as Monday – Friday, 7am – 4pm.
- **If known, in what environment will you be working this summer? Will you be assigned to a specific project, or will you spend your time in a specific department?**
    - **On-Site**: (26) students reported that they would be on a specific job site during their internship. These students reported a specific site at the time of the questionnaire.
    - **Department**: (6) students reported they would be working with specific departments within the company during their internships.
    - **Unsure**: (21) students reported they were unsure of where they would be placed for their summer internship. They may have made speculations, but were unsure of a specific placement.
- **If known, what types of activities do you expect to be doing during your internship this summer?**
    - **Management**: (35) students reported helping with management duties (i.e., paperwork)
    - **Physical Labor**: (4) students reported they expected to be working with a specific trade.
    - **Both**: (12) students reported they anticipated a combination of both management and physical labor duties.
    - **Uncertain**: (3) students reported they were unsure of their expected duties.
    - **NOTE**: Answers for this question were interpreted for ease of analysis. Answers were not limited to the specific choices listed above.
- **(Optional) If known, what compensation do you expect to receive for your work? Please list hourly wage, salary, or other compensation if you know it.**
    - The average reported wage for interns was $18.29/hr. The maximum reported wage was $20.80/hr and the minimum was $8.50/hr.
    - **NOTE**: Answers for this question were interpreted for ease of analysis. Some wages were reported on a weekly figure. In these cases, hourly wage was based on a 40-hour workweek.

Protocol 1 – Internship Information Analysis

Upon completion of Protocol 1, the results were analyzed to give a base demographic for the participants. The average student reported being a white male and either a sophomore or junior in college and had at least one internship prior to the time this survey was administered. The student has had little to no experience with sustainable practices and the experiences that were reported were listed as mostly academic, referring to a single class taught by the Building Construction Department at Virginia Polytechnic Institute and State University.

The companies with which students are interning are largely in the Commercial/Institutional sector, with some companies varying their portfolio to include Industrial and Residential. Over half of these companies are operating in the state of Virginia, but certain individuals are working as far south as Florida and north to Michigan. This is important because the majority of the information reported for this survey will relate to the companies that operate on the east coast, but may have satellite offices in other locations.

Participants reported being prepared to work on-site for their summer positions: however, some were unsure. Regardless, the majority of the participants were planning on working with management, rather than performing labor. The terms of the internship resulted in a 3-month employment from May to August, with average work hours from 7am to 4pm and wage of $18.29/hr.

Protocol 2: Corporate and Leadership Innovativeness Factors

Protocol 2 was the first one students implemented on the job. It was designed to guide students in collecting information about their company's perspectives on innovation. Innovation can be defined as something new or perceived to be new by the person adopting it, e.g., an innovative technology (Rogers 2003). It also refers to the process of introducing something new. In the context of the internship during the summer, the focus was on understanding how their company fits within the spectrum of innovativeness in general so that a better understanding of how it reacts to a specific type of innovation (sustainability) in later protocols could be assessed. The data collected and reported upon here helped to establish a baseline.

In the protocol, students were asked to collect information directly from the leader of the company, workgroup, or project through an interview, plus additional information that they could obtain from various other sources within their company. The questions focused upon individual and company innovativeness and the metrics by which the company defines success.

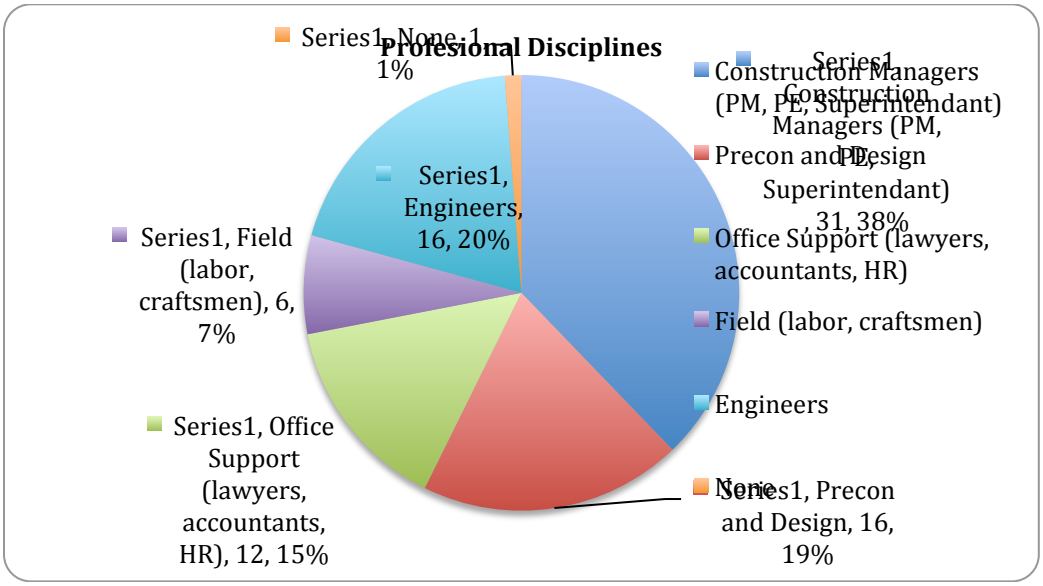
The following answers for Protocol 2 represent the demographics of the company and perceived innovativeness. These answers offer a glimpse into company practices and policies, as well as where the companies stand in comparison to the other participants in the survey. Certain questions were omitted from this report to maintain confidentiality. Additionally, some answers were modified to expedite the sorting process. These answers are noted in the report below.

Protocol 2 – Corporate and Leadership Innovativeness Factors Results

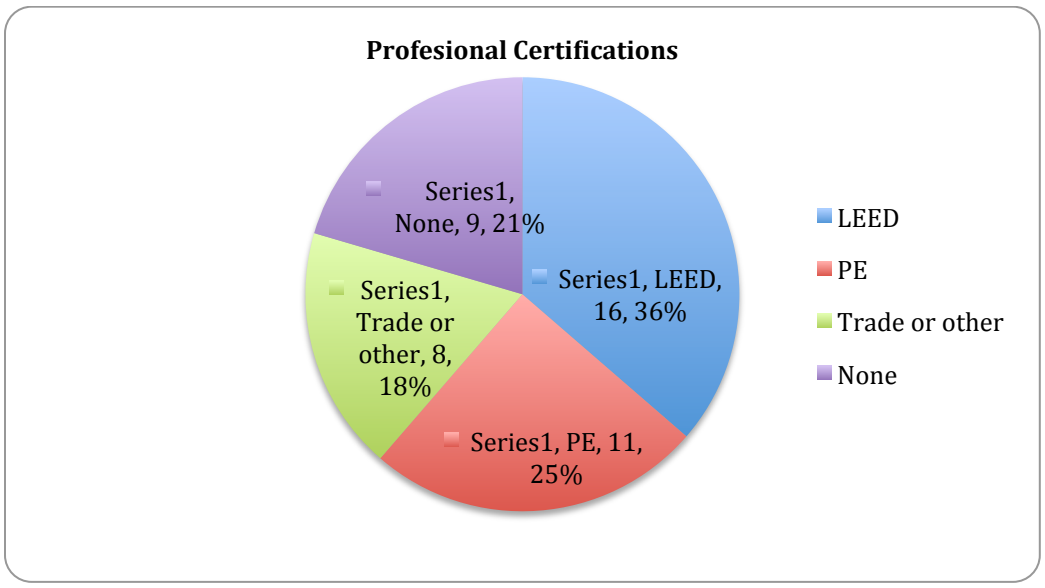
NOTE: For the following responses, three responses were inconsistent with corresponding answers and with the question. These answers were discarded. All other data was directly related to the questions and answers were consistent with correlating information.

- **In what organizations is your company a member?**
  - Most common responses were listed as
    - Associated Builders and Contractors (ABC),
    - The American Institute of Architects (AIA),
    - Occupational Health and Safety Administration (OSHA)
    - Association of General Contractors (AGC)
    - United States Green Building Council (USGBC)
  - Least common responses were listed as
    - Federal Electrical Contractors (FEC)
    - Mass Waterworks Association (MWA)

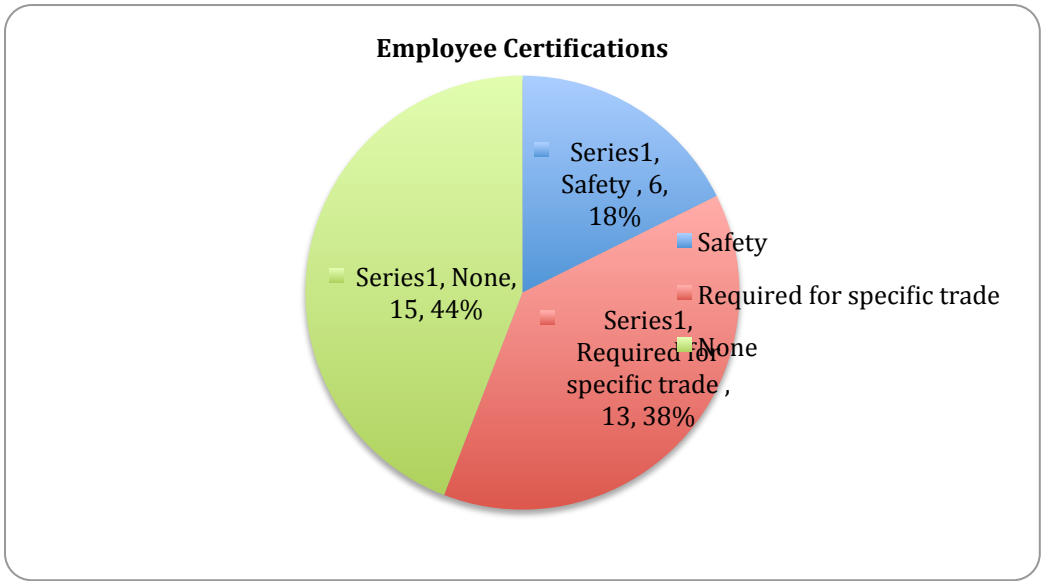
- **What disciplines of professionals does your company maintain in-house as full-time employees?**
  - Construction Managers (PM, PE, Superintendent) – 31
  - Preconstruction and Design – 16
  - Office Support (Lawyers, Accountants and HR) – 12
  - Trades (Labor, Craftsmen) – 6
  - Engineers – 16



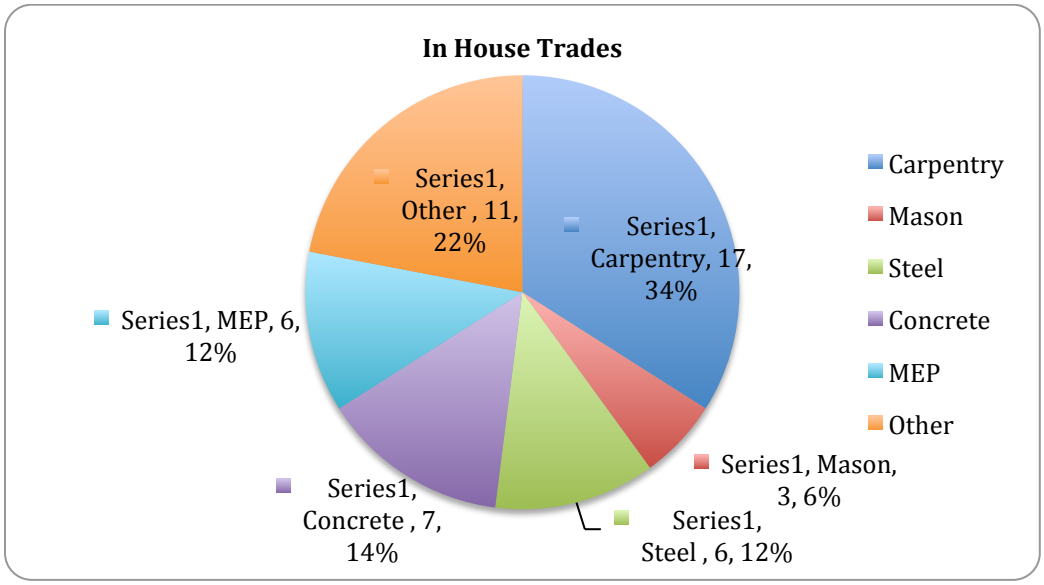
- **What professional certifications or accreditations do these employees maintain?**
  - Leadership in Energy and Environmental Design (LEED) – 16
  - Professional Engineer License (PE) – 11
  - Trade or other – 8
  - None – 9



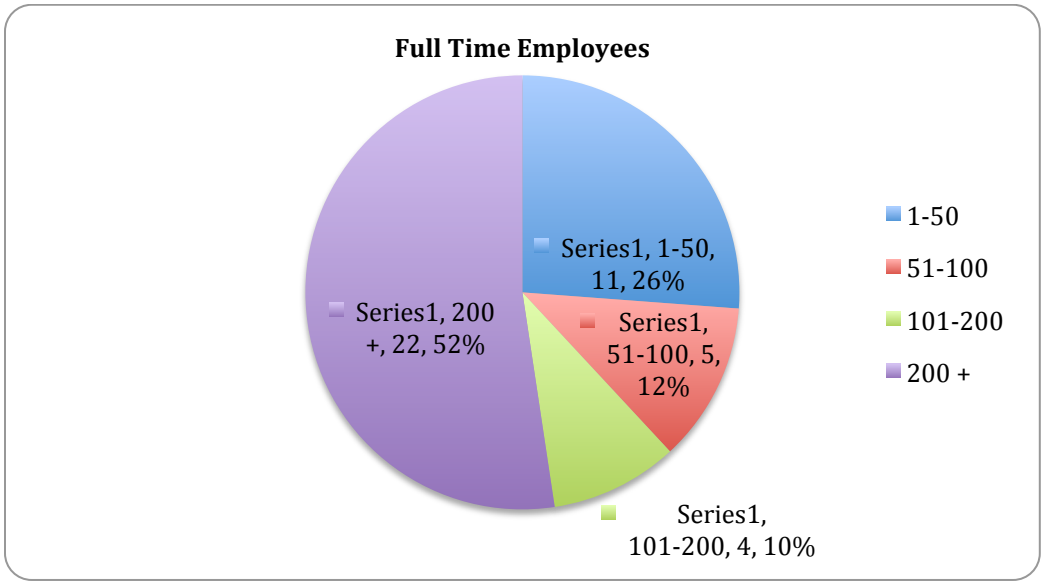
- **What certifications do your trade/craft employees maintain?**
  - Safety - 6
  - Required for specific trade - 13
  - Other – 15



- **What trades/crafts do you maintain in-house as full-time employees?**
  - Carpentry – 17
  - Masonry – 3
  - Steel – 6
  - Concrete – 7
  - MEP – 6
  - Other – 11

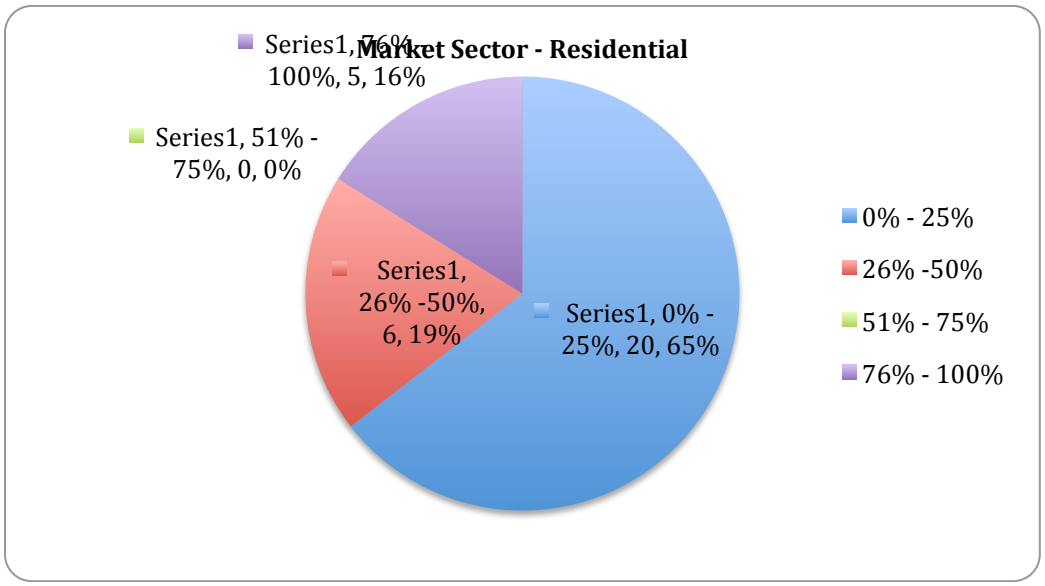


- **How many full-time employees does your company have in total?**
  - 1-50 employees – 11
  - 51-100 employees – 5
  - 101-200 employees – 4
  - 200+ employees – 22

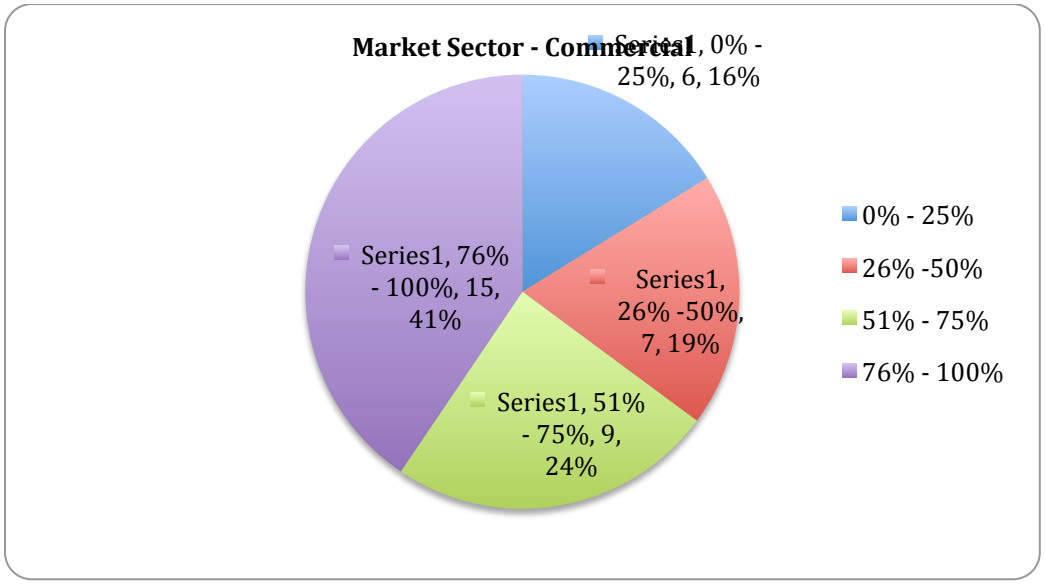


- **What is your annual turnover rate for employees?**
  - The average reported turnover rate for all respondents was 27.36%

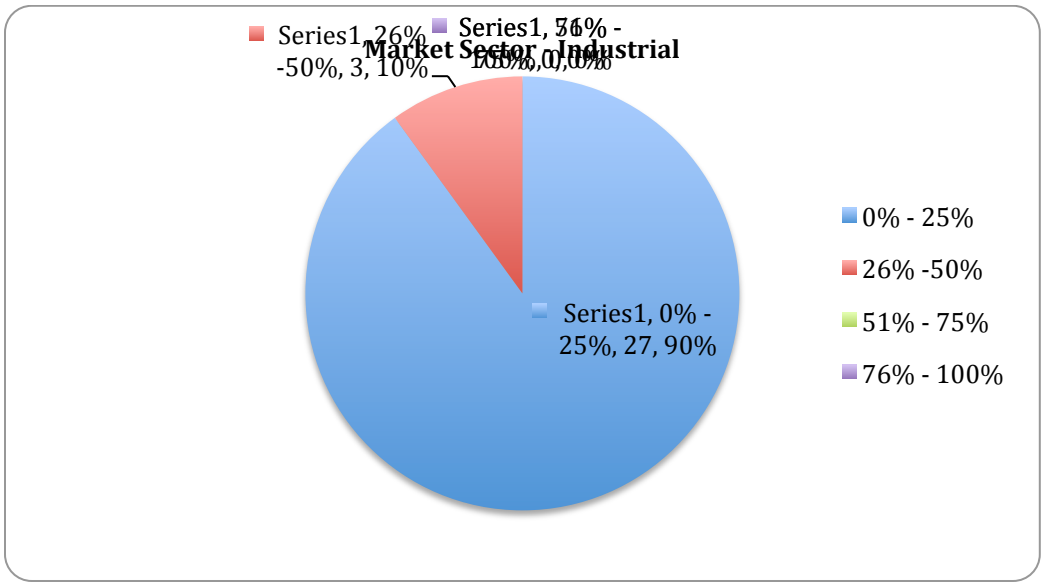
- **What market sector(s) does your firm target? Please estimate what percentage of your work is in each sector.**
    - **Residential**
        - 0%-25% - 20
        - 26%-50% - 6
        - 51%-75% - 0
        - 76%-100% - 5



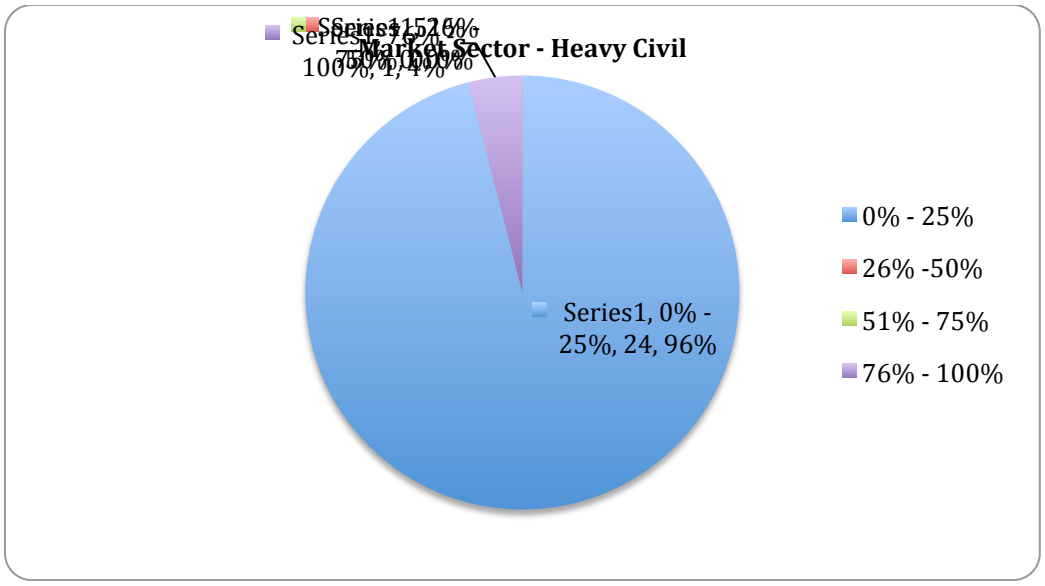
    - **Commercial**
        - 0%-25% - 6
        - 26%-50% - 7
        - 51%-75% - 9
        - 76%-100% - 15



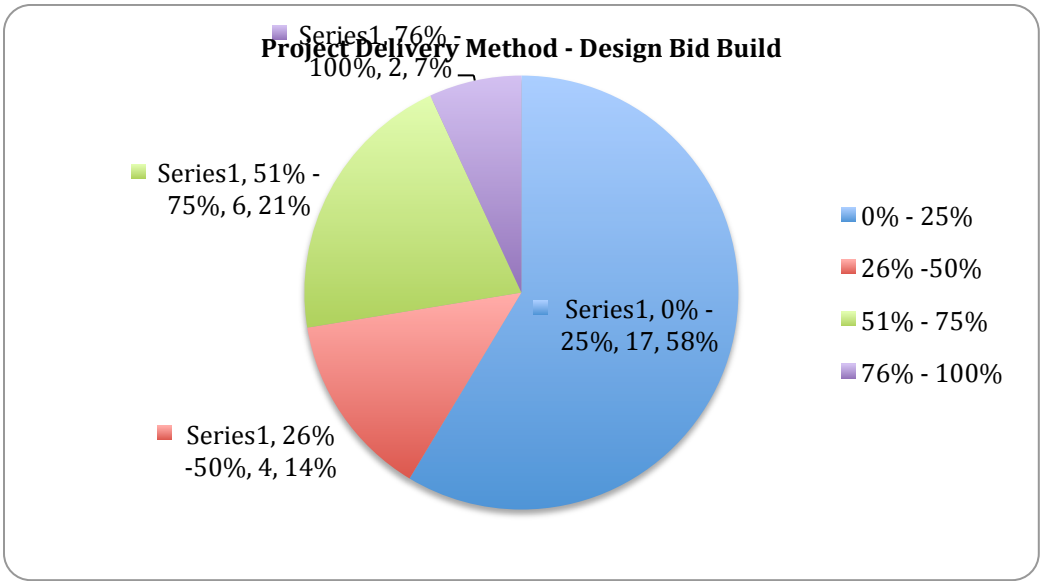
- **Industrial**
  - 0%-25% - 27
  - 26%-50% - 3
  - 51%-75% - 0
  - 76%-100% - 0



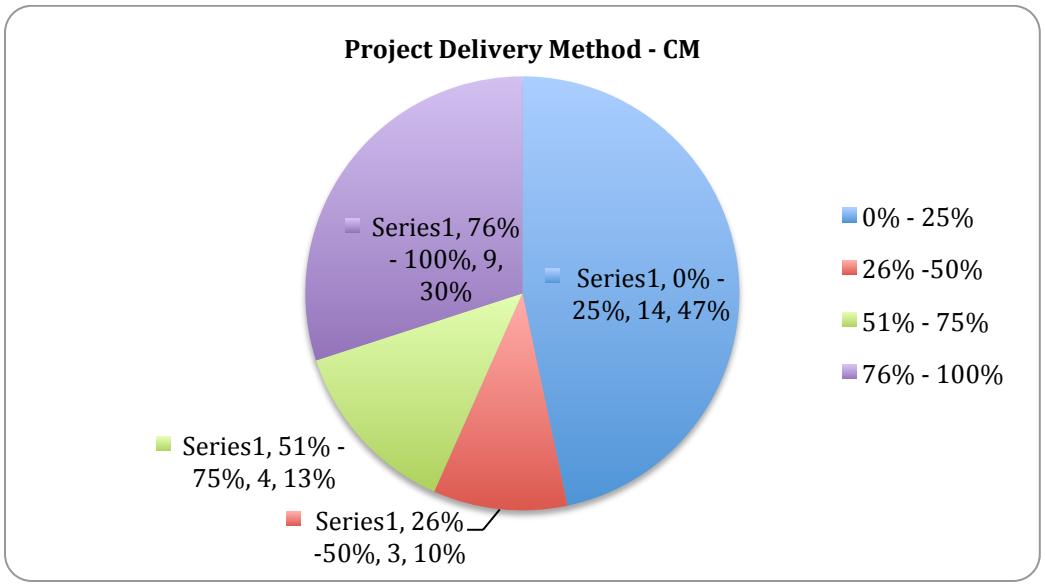
- **Heavy Civil**
  - 0%-25% - 24
  - 26%-50% - 0
  - 51%-75% - 0
  - 76%-100% - 1



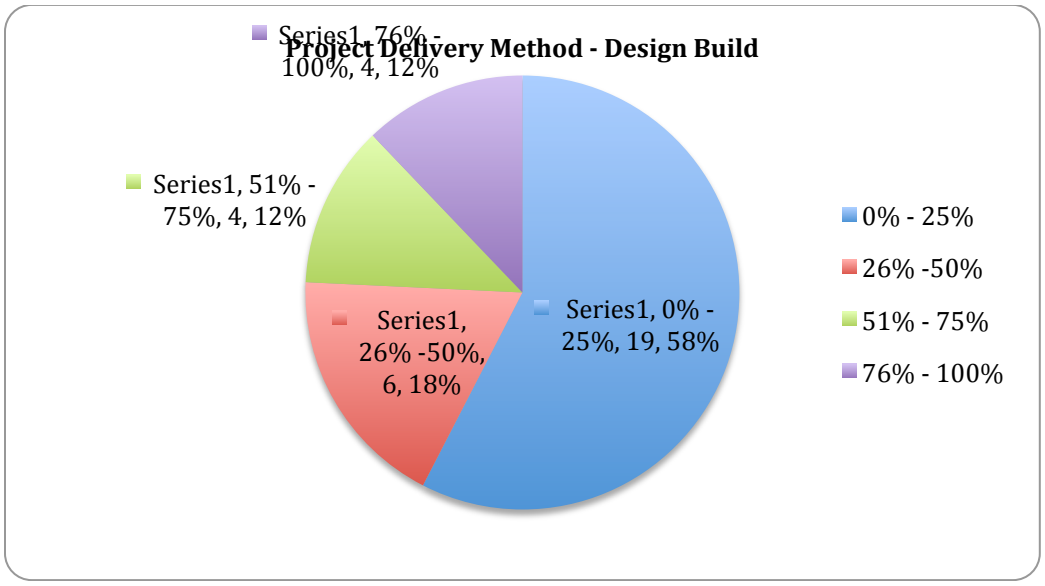
- **What types of project delivery methods does your firm use/become involved with? Please estimate what percentage of your work is in each project delivery method.**
    - **Design/Bid/Build percentage**
        - 0%-25% - 17
        - 26%-50% - 4
        - 51%-75% - 6
        - 76%-100% - 2



- **Construction Management percentage**
  - 0%-25% - 14
  - 26%-50% - 3
  - 51%-75% - 4
  - 76%-100% - 9



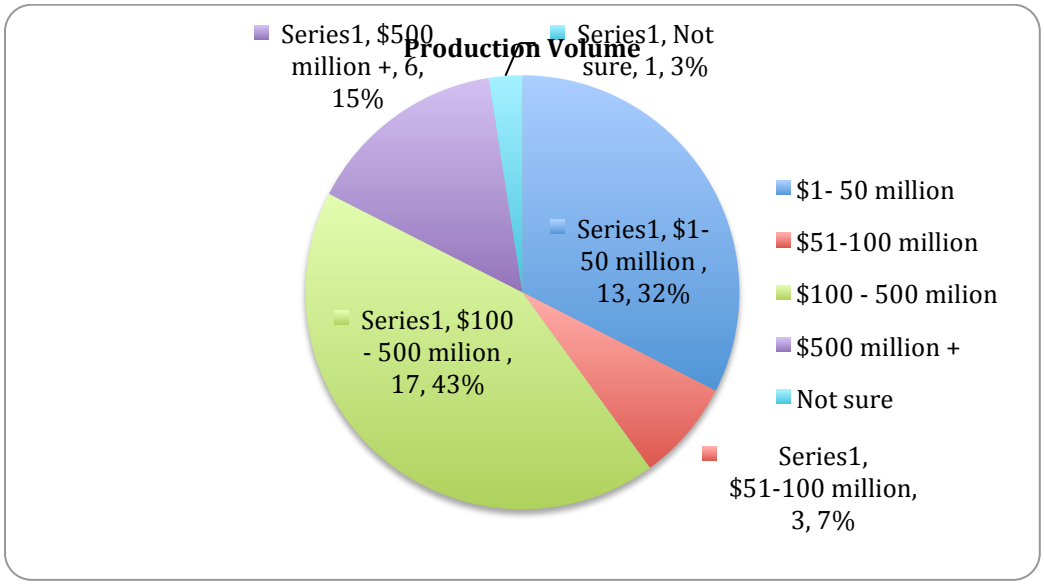
- **Design/Build percentage**
  - 0%-25% - 19
  - 26%-50% - 6
  - 51%-75% - 4
  - 76%-100% - 4



- **Other/comments about project delivery methods**
  - Typical answers included:

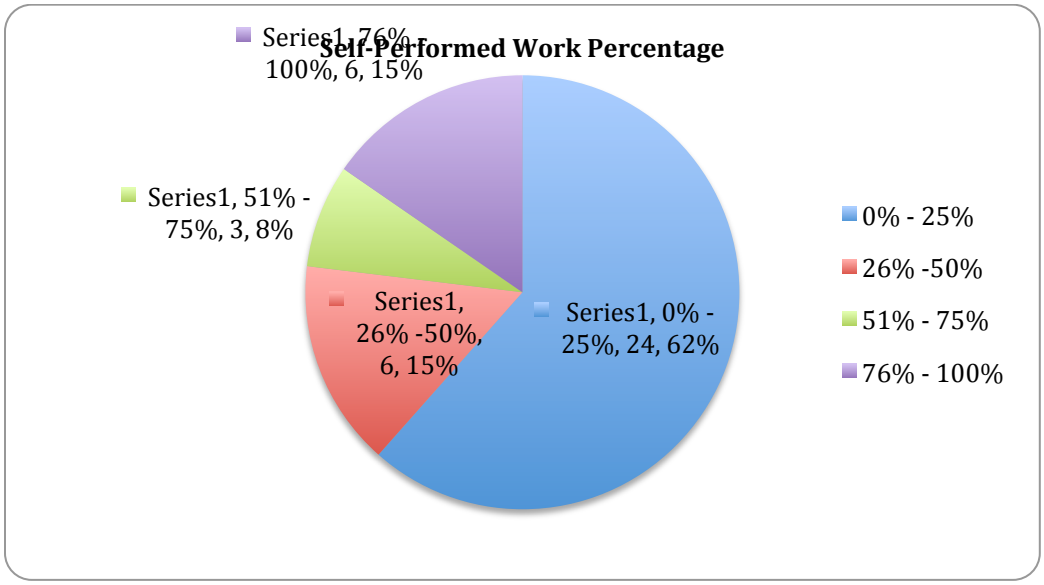
        - "80% negotiated (GMP contract), 20% hard bid (Lump Sum)"
        - "…they will do projects with the CM at risk and other plans that involve CM's acting in different roles"
    - Atypical answers included:
        - "Bidding is still most prominent, but design/build has seen an increase with repeating customers who were satisfied with the work"
        - "20% per plans and specs hard bid"

- **What was your total production volume for your most recent year?**
    - $1-50 million – 13
    - $51-100 million – 3
    - $100-500 million – 17
    - $500 million and over – 6
    - Not sure – 1

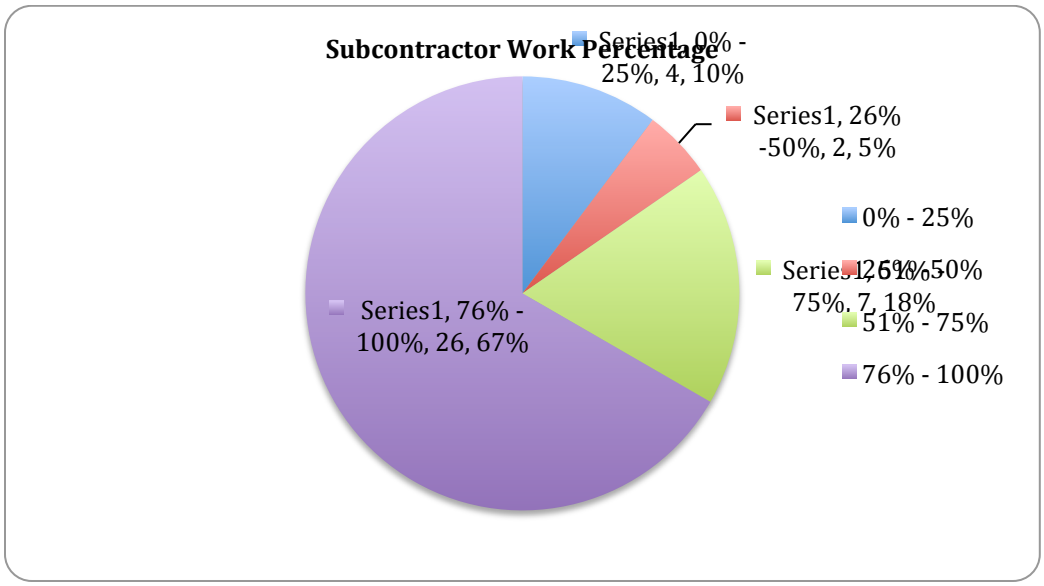


- **What percentage of your work is self performed vs. performed by contractors?**

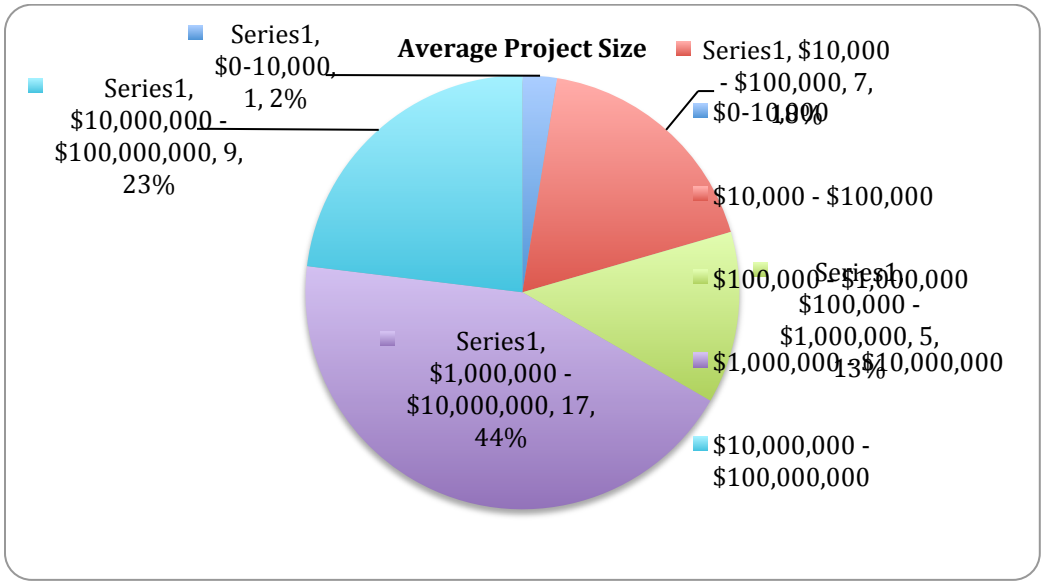
    - **Self-performed percentage**
        - 0%-25% - 24
        - 26%-50% - 6
        - 51%-75% - 3
        - 76%-100% - 6



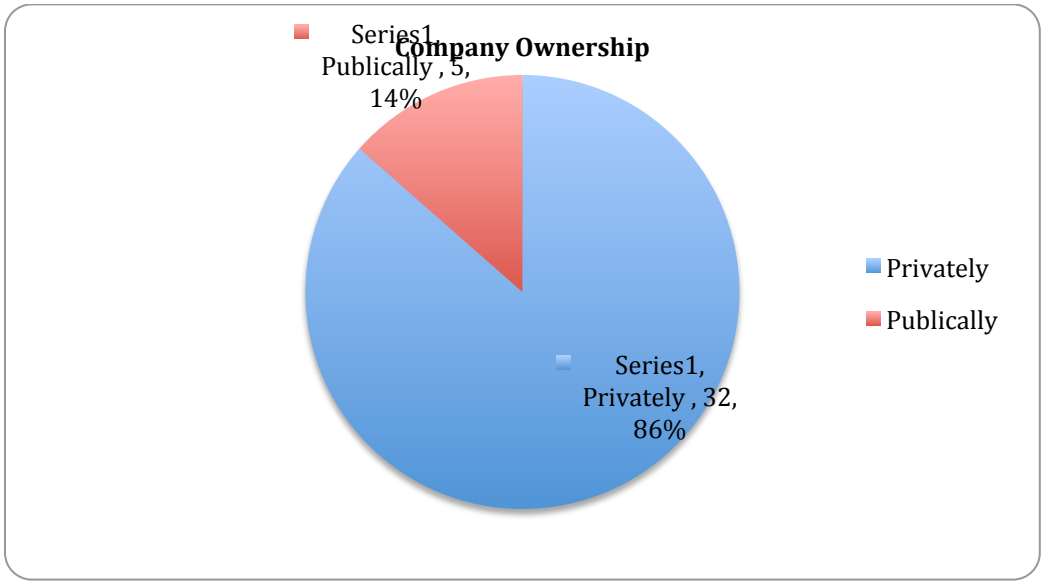
- **Performed by subcontractors percentage**
  - 0%-25% - 4
  - 26%-50% - 2
  - 51%-75% - 7
  - 76%-100% - 26



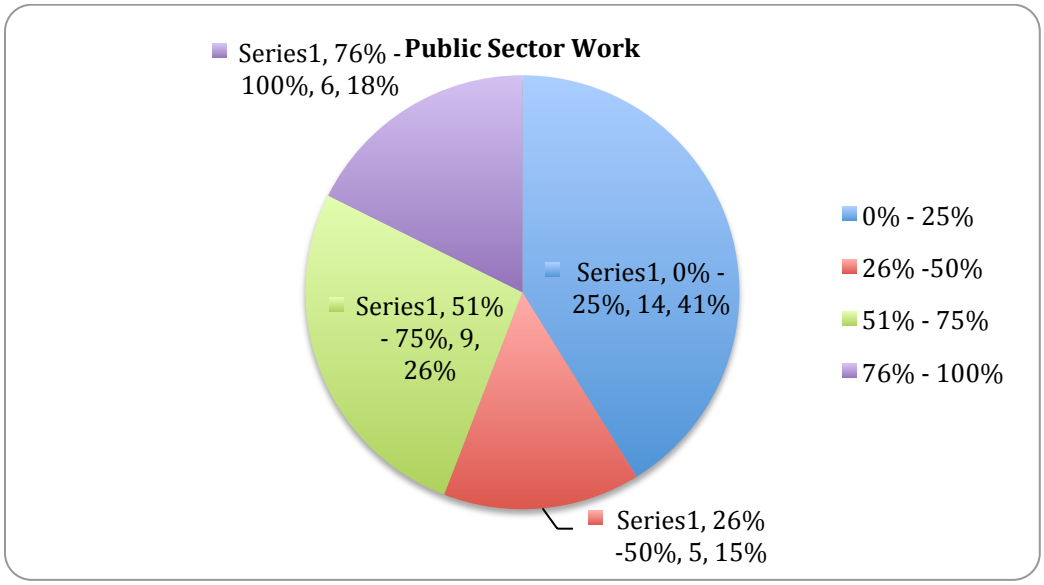
- **Which of the following amounts is closest to your average project size?**
  - $0-$10,000 – 1
  - $10,000-$100,000 – 7
  - $100,000-$1,000,000 – 5
  - $1,000,000-$10,000,000 – 17
  - $10,000,000-$100,000,000 – 9



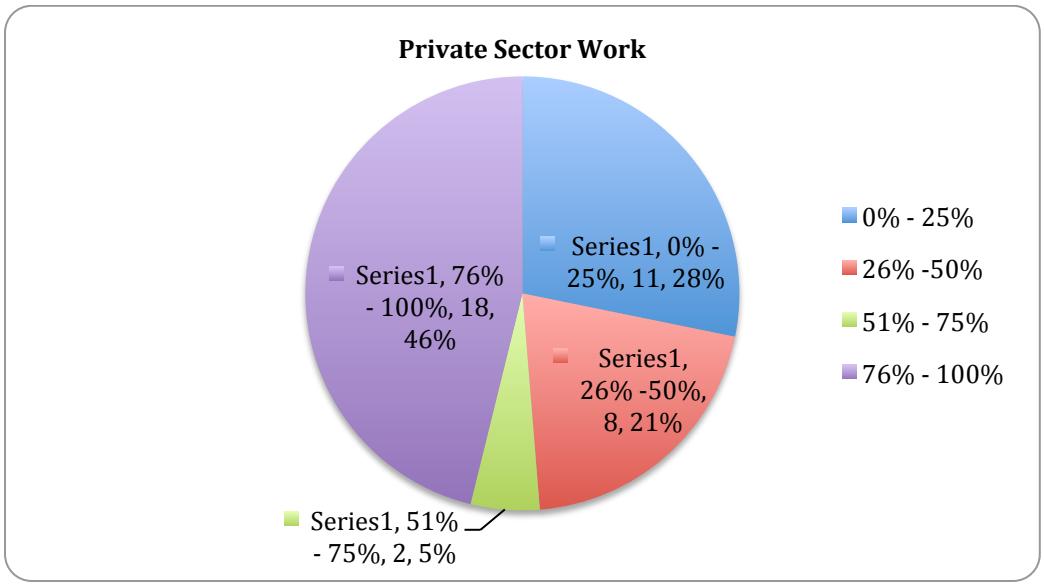
- **Is your company publicly or privately owned?**
  - Privately – 32
  - Publically – 5



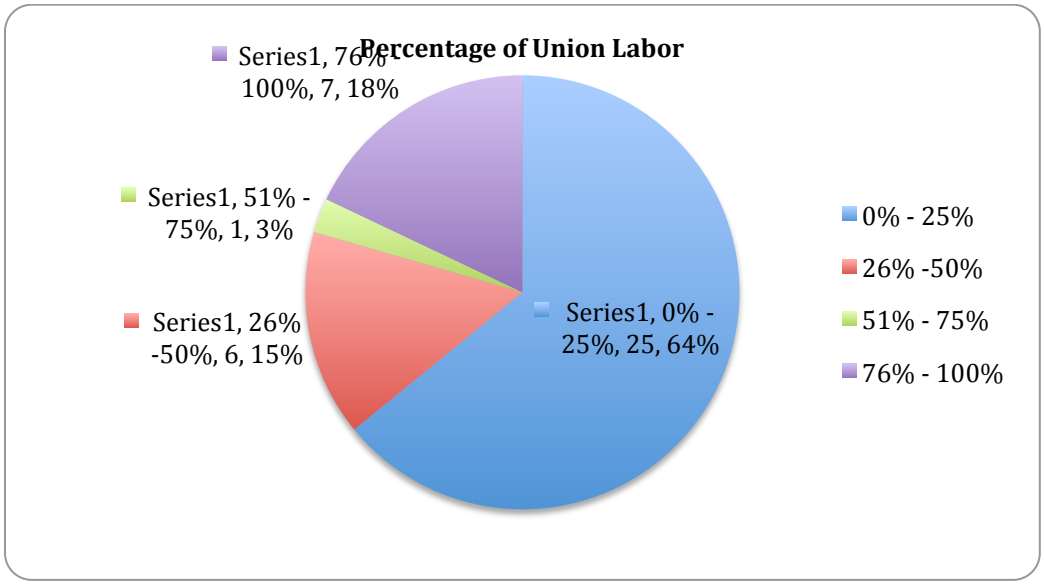
- **What percentage of your work is for public sector owners vs. private sector owners?**
  - **Public sector owner's percentage**
    - 0%-25% - 14
    - 26%-50% - 5
    - 51%-75% - 9
    - 76%-100% - 6



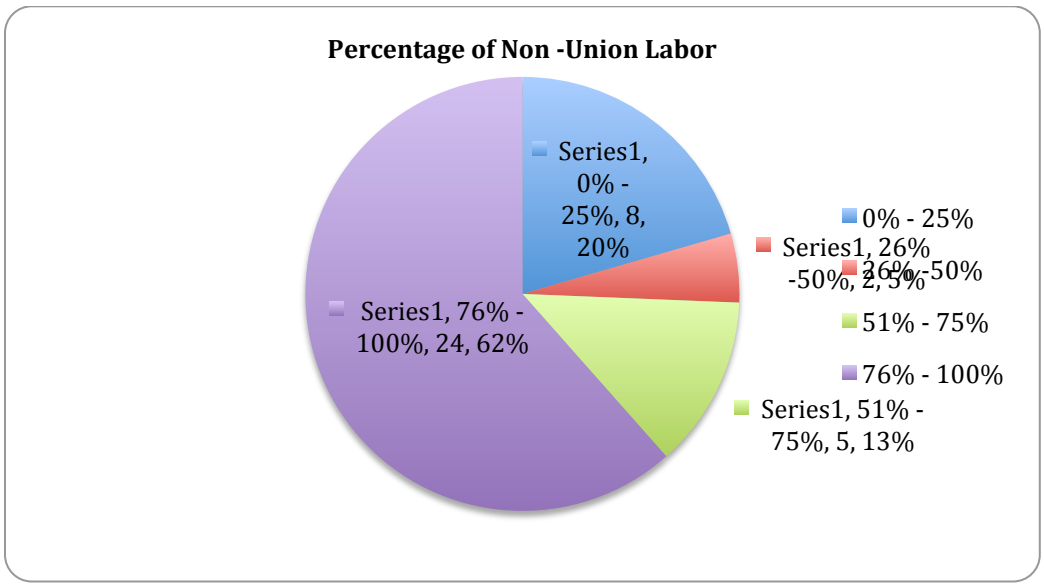
- **Private sector owner's percentage**
  - 0%-25% - 11
  - 26%-50% - 8
  - 51%-75% - 2
  - 76%-100% - 18



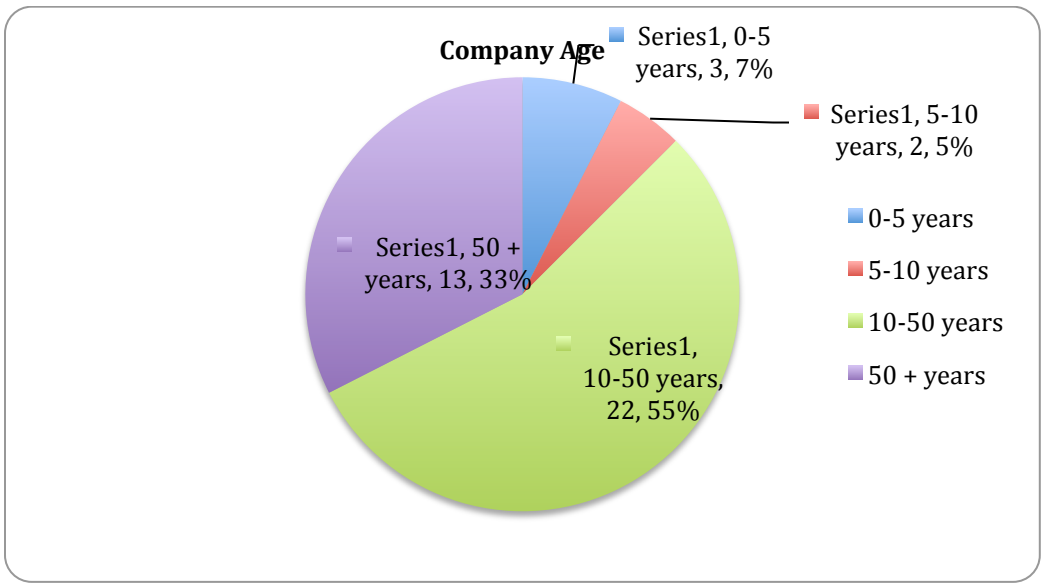
- **What percentage of your work uses union labor?**
  - **Union labor percentage**
    - 0%-25% - 25
    - 26%-50% - 6
    - 51%-75% - 1
    - 76%-100% - 7



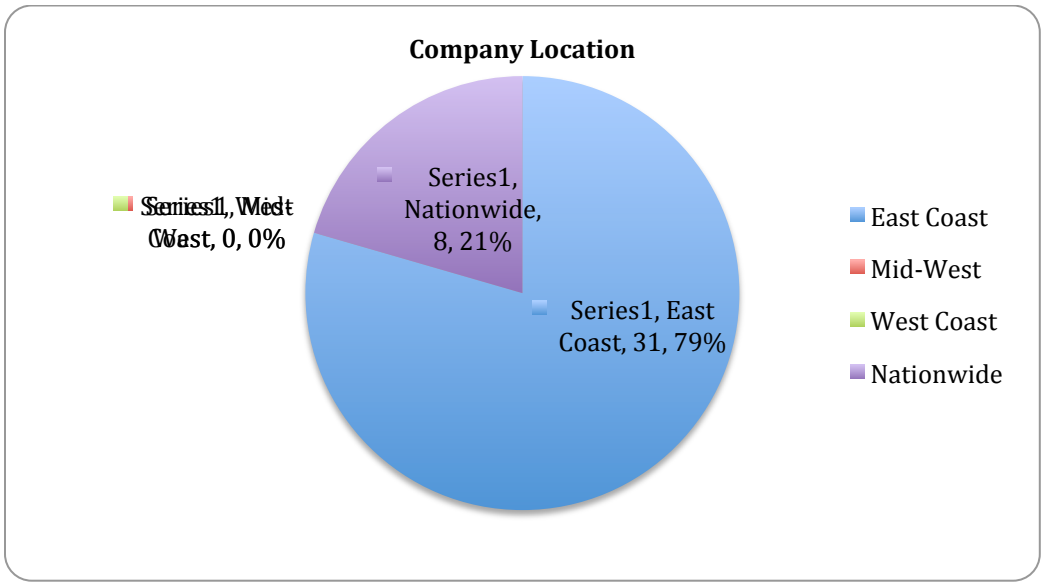
- **What percentage of your work uses union labor?**
    - **Non-union labor percentage**
        - 0%-25% - 8
        - 26%-50% - 2
        - 51%-75% - 5
        - 76%-100% - 24



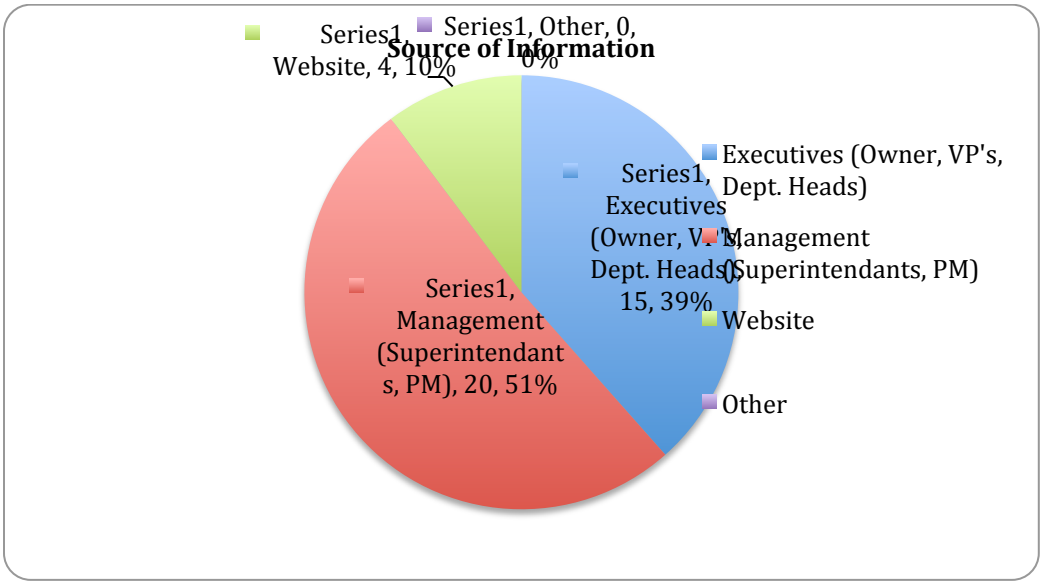
- **How old is your company?**
    - 0-5 years – 3
    - 5-10 years – 2
    - 10-50 years – 22
    - 50 years and over – 13



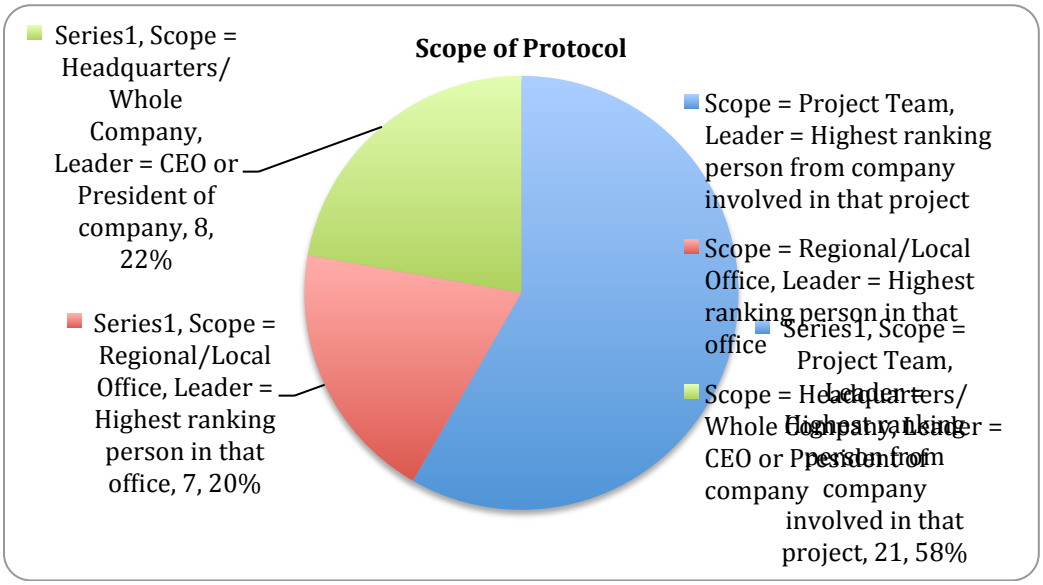
- **Where is your company located? Please list cities and states for all main offices and indicate which one is the headquarters location.**
  - East Coast – 31
  - Mid-West – 0
  - West Coast – 0
  - Nationwide – 8



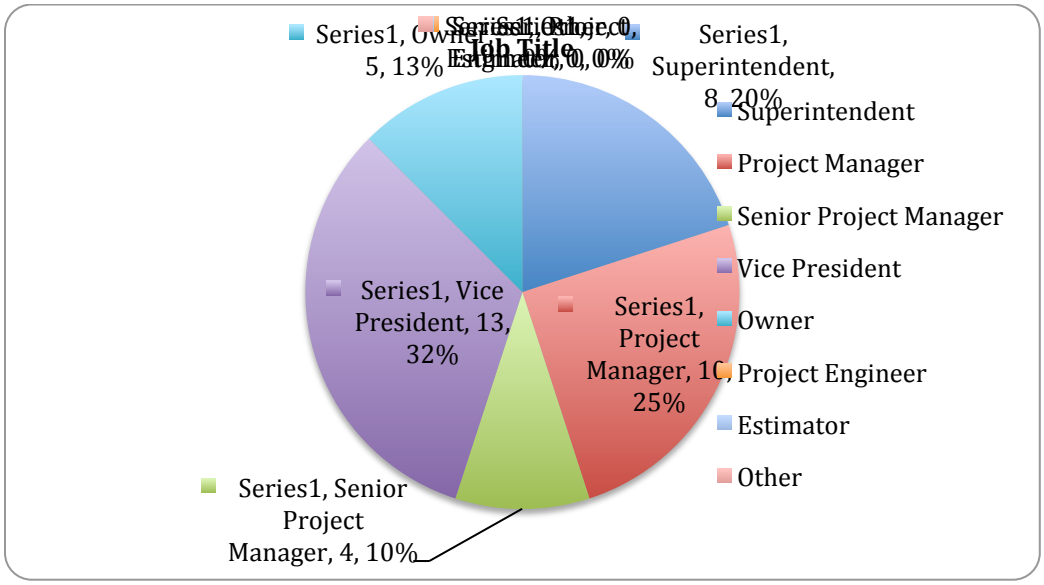
- **Please indicate where you received most of the above information (i.e. website, human resources, manager.)**
  - Executives (Owners, Vice Presidents, Department Heads) – 15
  - Management (Superintendents, Project Managers) – 20
  - Website - 4
  - Other – 0



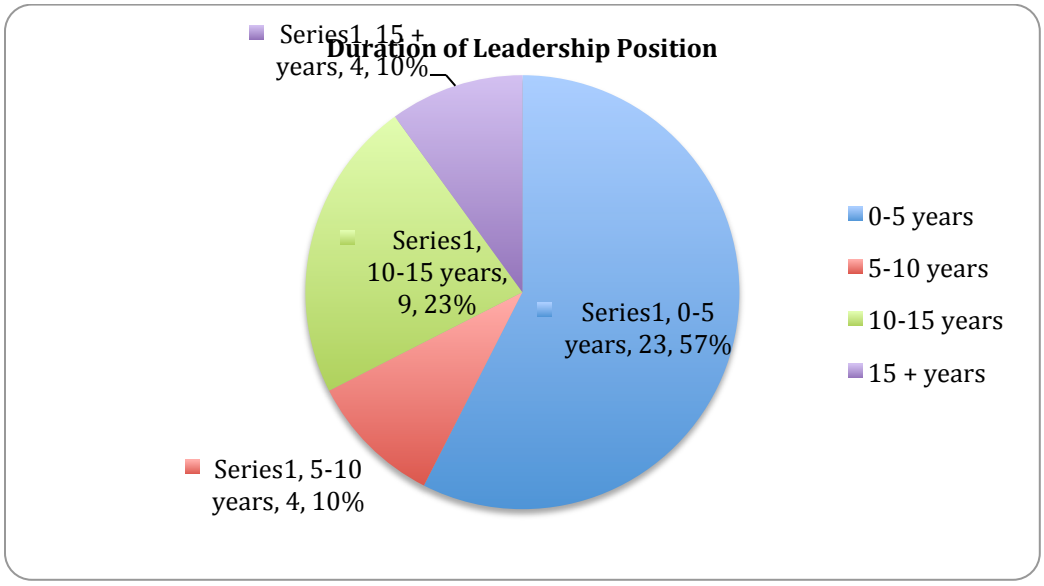
- **Which of the following options best describes the scope you've selected to pursue for this protocol?**
  - Project Team Leader = Highest ranking person from company involved in that project - 21
  - Regional/Local Office Leader = Highest ranking person in that office - 7
  - Headquarters/Whole Company Leader = CEO or President of company – 8



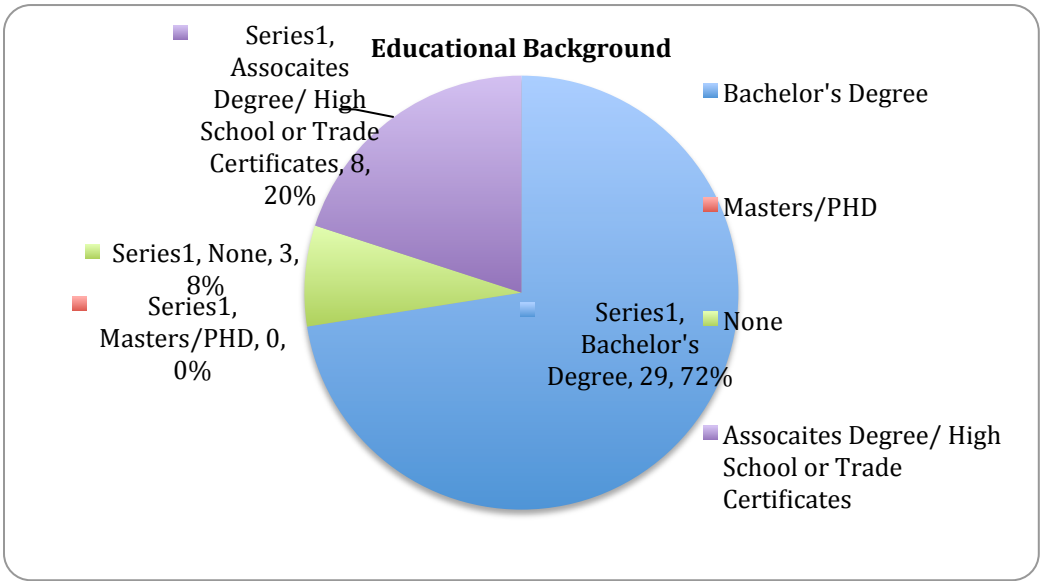
- **Job Title**
  - Superintendent – 8
  - Project Manager – 10
  - Senior Project Manager – 4
  - Vice President – 13
  - Owner – 5
  - Other – 0



- **How long have you been serving in this leadership position?**
  - 0-5 years – 23
  - 5-10 years – 4
  - 10-15 years – 9
  - 15 years and over – 4



- **What is your educational background?**
  - Bachelor's Degree – 29
  - Masters/PhD. – 0
  - None – 3
  - Associates Degree/High School or Trades Certificates – 8

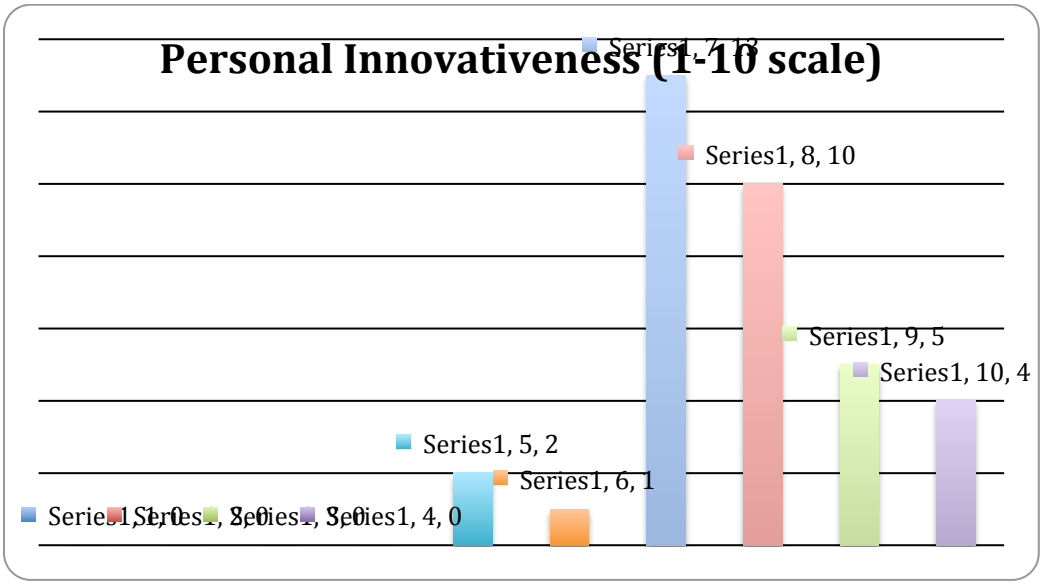


- **What was your job history before your current position?**
  - Typical answers included:
    - "Field engineer for 2 years, then 3 years as a project engineer, and finally 1 year as a PM "
    - "7 years for [company] and 11 years in different management positions"
  - Atypical answers included:
    - "Worked for Toyota as safety official"
    - "Sales and Marketing Manager for a radio station"

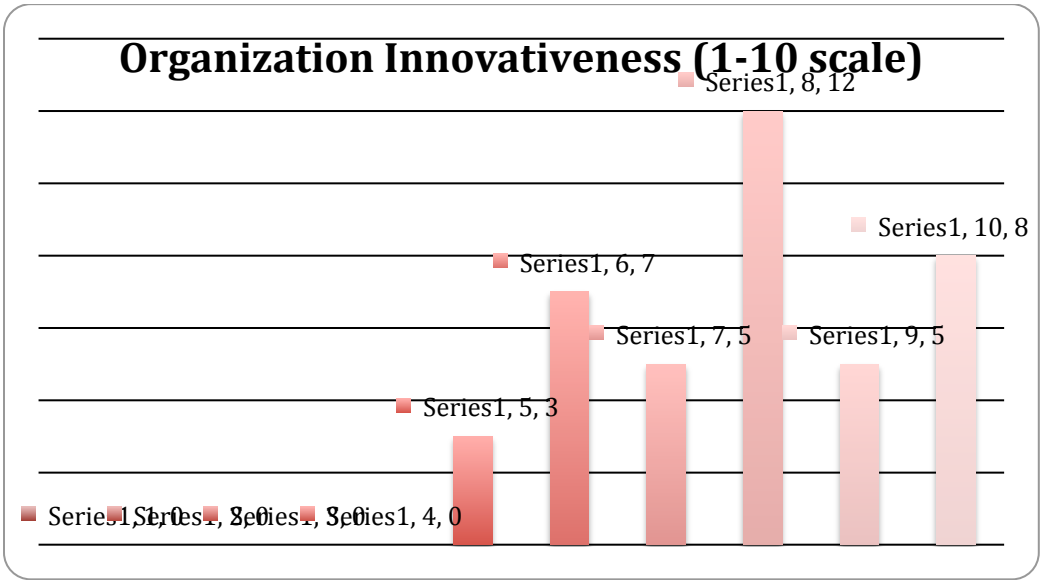
- **Over a typical week, how do you spend your time? In the office? In the field? With clients? At external meetings? Other?**
  - Typical answers included:
    - "Office=60% Field=30% Clients=5% Meetings=5%"
    - "75% - In the Office 10% - In the Field 10% - At External Meetings 5% - Other"
  - Atypical answers included:
    - "He said "worrying" But then he said that he does all of these things evenly throughout the week "
    - "All of the above, office, field, with clients, external meetings, etc..."

- **In which professional or technical organizations do you hold a membership**?
  - **Most common answers ranged from**
    - "None"
    - "AGC"
  - **Least common answers ranged from**
    - "Women in Construction"
    - "Mass Highway Certified"

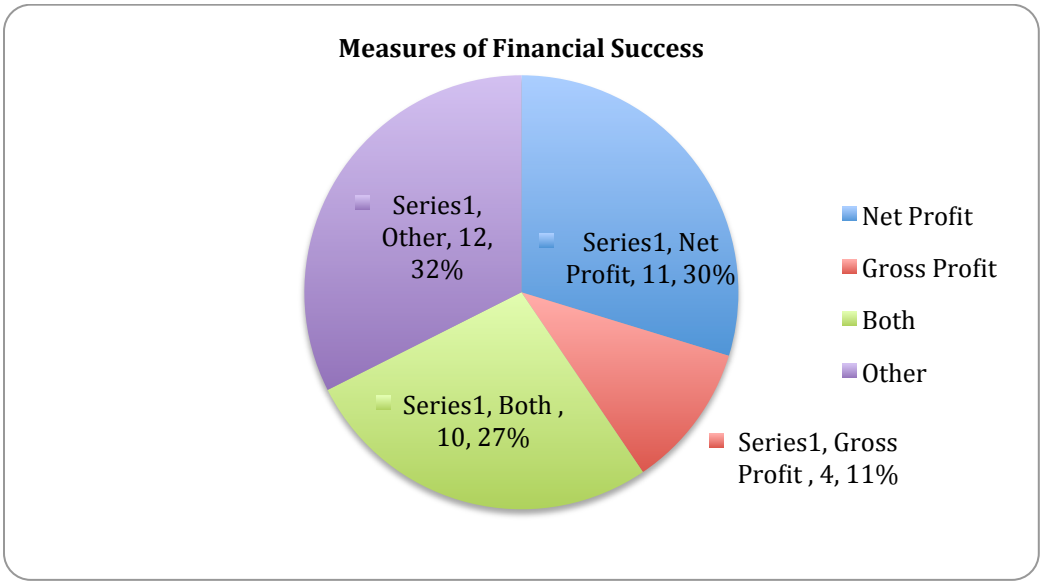
- **On a scale of 1 to 10, how innovative would you say you are personally?**
  - 1 - 0
  - 2 - 0
  - 3 - 0
  - 4 - 0
  - 5 - 2
  - 6 - 1
  - 7 - 13
  - 8 - 10
  - 9 - 5
  - 10 – 4



- **On a scale of 1 to 10, how innovative would you say your organization is?**
  - 1 - 0
  - 2 - 0
  - 3 - 0
  - 4 - 0
  - 5 - 3
  - 6 - 7
  - 7 - 5
  - 8 - 12
  - 9 - 5
  - 10 – 8



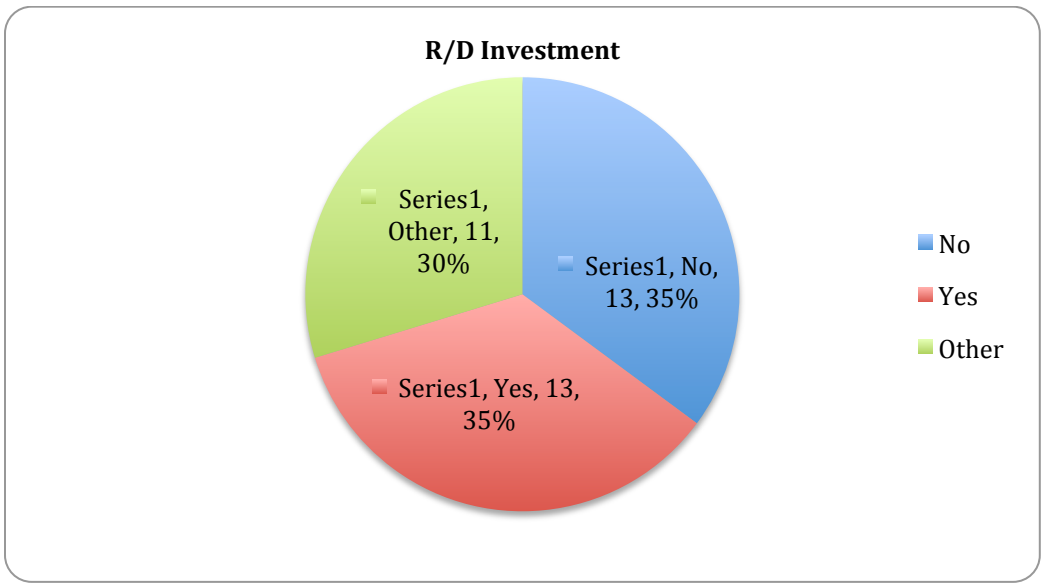
- **What financial measures do you use to define the success of your company?**
  - Net profit – 11
  - Gross profit – 4
  - Both – 10
  - Other – 12



- **In the context of these measures, how has your company performed over the past five years?**
  - Typical answers included:
    - **"**Extremely well**"**
    - **"**Very Profitable**"**
  - Atypical answers included:
    - "Didn't say exactly but they've met their goals for the past few years"
    - "Highly successful, the company's daily receivables are lower than the national average."

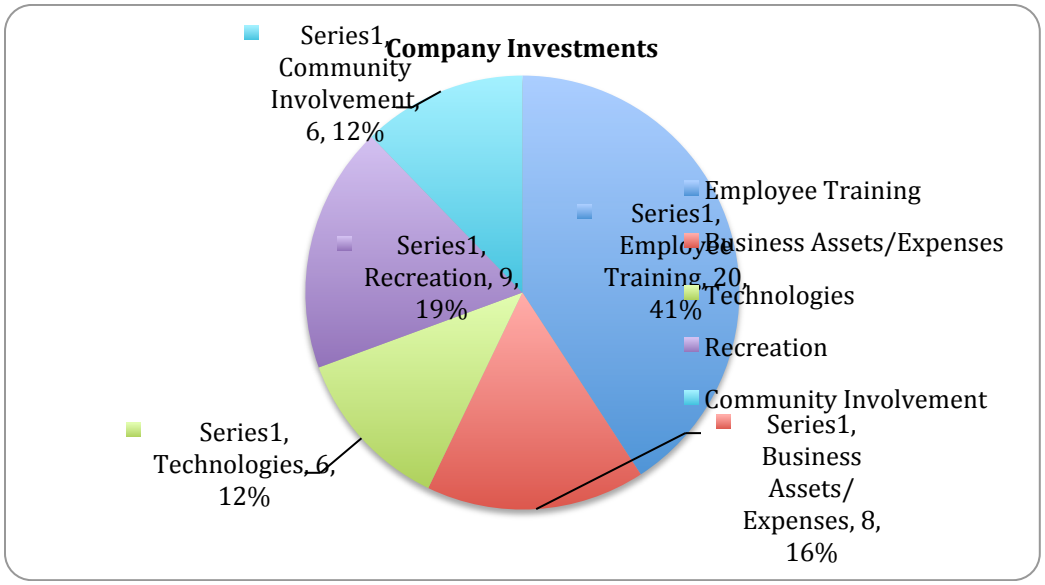
- **What is your targeted level of performance over the next five years?**
  - Typical answers included:
    - "3 Billion in work"
    - "$150 million"
  - Atypical answers included:
    - "Return on labor, Fee percentage, 70 percent repeat business, Low employee attrition"
    - "Well above national average"

- **Does your company invest in research and development?**
  - Yes – 13
  - No – 13
  - Other – 11

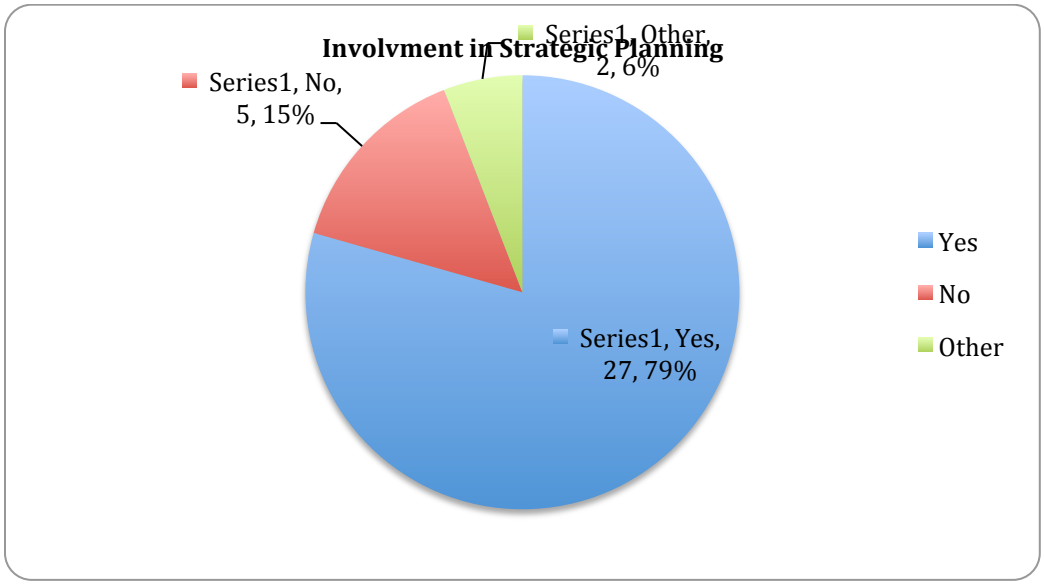


- **What other non-project specific or "overhead" activities or resources does your company invest in to support the business as a whole?**
  - Employee Training – 20
  - Business Assets/Expenses – 8
  - Technologies – 6
  - Recreation – 9
  - Community Involvement – 6

NOTE: Answers counted more than once due to range in answers.



- **Does your company engage in strategic planning? If so, what does it do? What time frame?**
  - Yes – 27
  - No – 5
  - Other – 2



- Typical answers included:
  - "Yes, weekly executive meetings, educational courses"
  - "Yes - 1 year, 5 year, and long-term plans"
- Atypical answers included:
  - "There is no limited strategy. The company has an understood philosophy to be profitable, grow with opportunities, take advantage of them, and have fun"
  - "Sends employees to seminars, also reimburses employees for furthering their education. Team building activities include company softball teams and other outside of work teams"

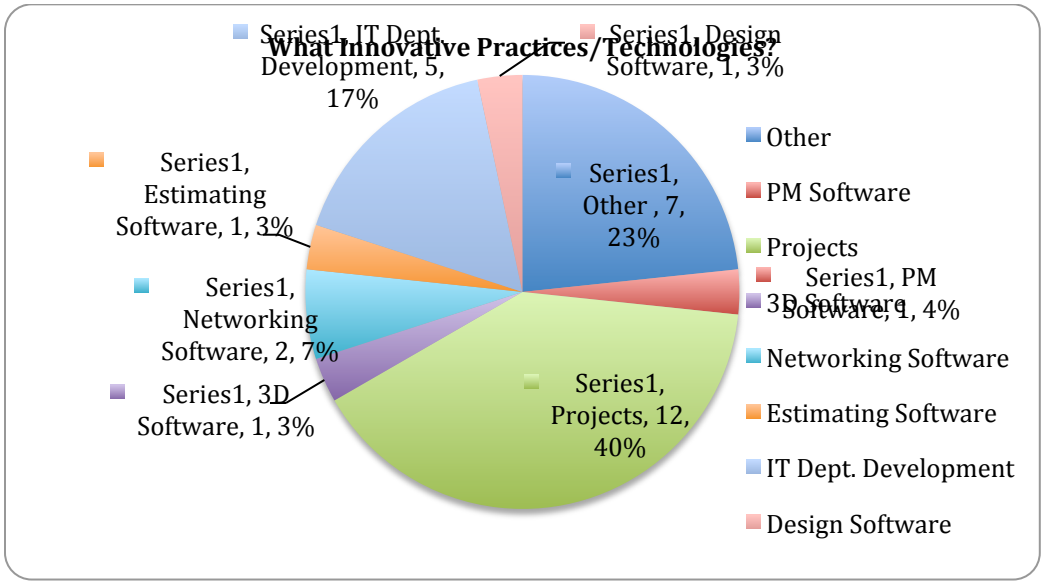
- **Does your company provide any incentives or mechanisms to encourage its employees to be innovative or come up with new ideas? If so, what do you do?**
  - Yes – 23
  - No – 9
  - Other – 0

  - Typical answers included:
    - "We offer bonuses due to job efficiency (depending on if the job is done smoothly and in a timely fashion). I also provide incentives by showing appreciation and appraising employees on a job well done. "
    - "There is a bonus program in place for jobs that finish early, or make an unexpected amount of profit. There is also an "Employee of the Year" which is announced annually around Christmas time."
  - Atypical answers included:
    - "No incentives except to improve the company."
    - "There are no added incentives. The company wants one to understand and take responsibility for his/her job and do one's best."

- **How tolerant is your company if a new idea proposed by an employee doesn't turn out as expected?**
  - Tolerant – 32
  - Not Tolerant – 1
  - Other – 2

- **How does your company stay informed about new products and technologies?**
  - Typical answers included:
    - **"**Internet, Reading National Publications (ex ENR), and trade organizations"
    - **"**Home shows, talking to other companies and subcontractors"
  - Atypical answers included:
    - **"**Customer feedback in surveys**"**
    - **"**Dodge reports**"**

- **In your opinion, what is the most innovative thing your company has undertaken in the past five years?**
  - Other - 7
  - PM Software – 1
  - Project Specific – 12
  - 3D Software – 1
  - Networking Software – 2
  - Estimating Software – 1
  - IT Dept. Development – 5
  - Design Software – 1



Protocol 2 – Corporate and Leadership Innovativeness Factors Analysis

The results from Protocol 2 display companies that are members of organizations that are specific to and requirements of the markets that companies work in. To operate in these markets, the majority (38%) employ construction management positions including Project Managers and Superintendents, with smaller percentages of positions representing Pre-construction and Design (20%), engineers (20%) office support (15%) and trades (7%). Companies in this survey reported that the most common certification among their employees were LEED accreditation, followed by a Professional Engineering license, and trade certifications and no certifications were tied for the least common answer. Additionally, these companies mainly employ carpentry trades and the vast majority employs over 200 employees with a 27.4% turnover rate. This data implies that the most of the companies are large players in the commercial markets and take LEED certification and practices seriously as an emerging movement and not a trend.

Moreover, the data collected in this survey is represents companies that are fairly old in life cycle, 55% between 10-50 years with most of the answers coming from employees that have been serving in their current leadership position within the company for 5 years or less (58%). The most commonly reported job title was Vice-President (33%) followed by Project Manger (25%), and Superintendent (20%). There were no Masters/Ph.D. degrees noted, although (73%) reported having a Bachelor's degree in a related field. Interestingly, the average Vice-President interviewed has been serving for less than 5 years and has an average educational level of a B.S. This may suggest that the value of higher level of education is invaluable to the industry or that the higher degrees are a newer trend in academic institutions.

The average company representative reports his or her company as a highly innovative organization using profit as the main benchmark for success. Overall, the responses of the survey suggest that companies are actively engaged in the development of their company and employees through a variety of sources. Employee training (41%) and project specific innovations (52%) are the most common investments and over 91% of employees report themselves be tolerant of new ideas.

Protocol 3: Baseline Sustainability Best Practices

Having successfully completed Protocol 2 about company innovativeness and the innovativeness of its leader(s), Protocol 3 was designed to establish a baseline of the best practices followed by each company with regard to sustainability. Students were tasked to observe current practice both for general office procedures as well as for their company's projects, and to also ask questions of the people in charge of these practices.

The focus of this assignment was to determine what practices each company currently uses at the corporate and project levels that represent sustainability best practices. For each of the practices in the developed checklist, students were asked to either observe directly whether or not it is being used in the company, or ask someone in the company whether it is being used. The project-specific practices in particular required students to work with someone in the company to find out whether or not the practices are used on *other* projects besides the one on which they may be working.

Protocol 3 – Baseline Sustainability Best Practices Data Results

The following answers for protocol 3 represent the baseline sustainability practices that are currently in use by each company. This answer set aims to explore what practices are employed, why they are employed, and if they are successful or a burden. This protocol was split into two main sections. The first section presented thirty-five sustainable practices where the participants were asked to answer "Yes" or "No" as to whether their company employs the practice in question. This series of questions helps to establish a baseline for the companies to be compared against. The second section of this protocol (labeled Protocol 3a – 3k), refers to project-level sustainable practices that the company may have tried and abandoned or never tried at all. These questions help to gauge what practices are prominent and which ones are not useful or efficient for the companies. Certain questions were omitted from this report to maintain confidentiality. Additionally, some answers were modified to expedite the sorting process. These answers are noted in the report below.

Protocol 3: Baseline Sustainability Best Practices Section 1

Protocol 3 – Baseline Sustainability Best Practices Section 1 Results

Table 1 - Baseline Sustainability Best Practices

Practice	YES	NO
1. A formal process for capturing lessons learned	31	9
2. A recycling program for office waste	31	9
3. Employees with sustainability expertise	29	11
4. Access to external sustainability specialists/partners	28	11
5. A community/social service program	24	16
6. Energy-efficient office equipment	24	16
7. A policy of letting employees participate in external committees	23	16
8. A program for reusing resources (e.g., coffee mugs)	22	18
9. Technical information on our green practices	21	19
10. A formal policy on sustainability	19	21
11. Green team(s) or sustainability working groups	19	21
12. Marketing information on our green practices	19	21
13. A web site or newsletter on sustainability programs	18	22
14. A strategic plan for sustainability implementation	18	22
15. A teleconference-instead-of-travel policy	18	22
16. A telecommuting/flex time policy	16	24
17. An orientation program that includes sustainability or social/environmental issues	14	26
18. A program for customer/client education on sustainability	14	25
19. A policy of sustainable/green purchasing/procurement	14	26
20. Listings in major green guides/directories for our products/services	11	29
21. Lunch n' learn programs on sustainability	11	29
22. An environmental accounting system (e.g., triple bottom line)	10	30
23. A program for supply chain education on sustainability	9	31
24. Formal sustainability metrics/evaluation program	9	30
25. Regular sustainability audits of our products/processes	9	31
26. Bicycle facilities/carpool incentives	9	31
27. A policy of "paperless" operations	9	30

28. Transit passes for employees	8	32
29. A program for greening its own capital facilities	7	32
30. An annual environmental report to shareholders/stakeholders	7	33
31. An environmental code of conduct for employees	5	35
32. A green housekeeping program	4	36
33. Alternative fuel fleet vehicles	4	36
34. A green investment program for retirement/pension plans	1	39
35. A green travel policy (e.g., environmentally friendly hotels)	0	40

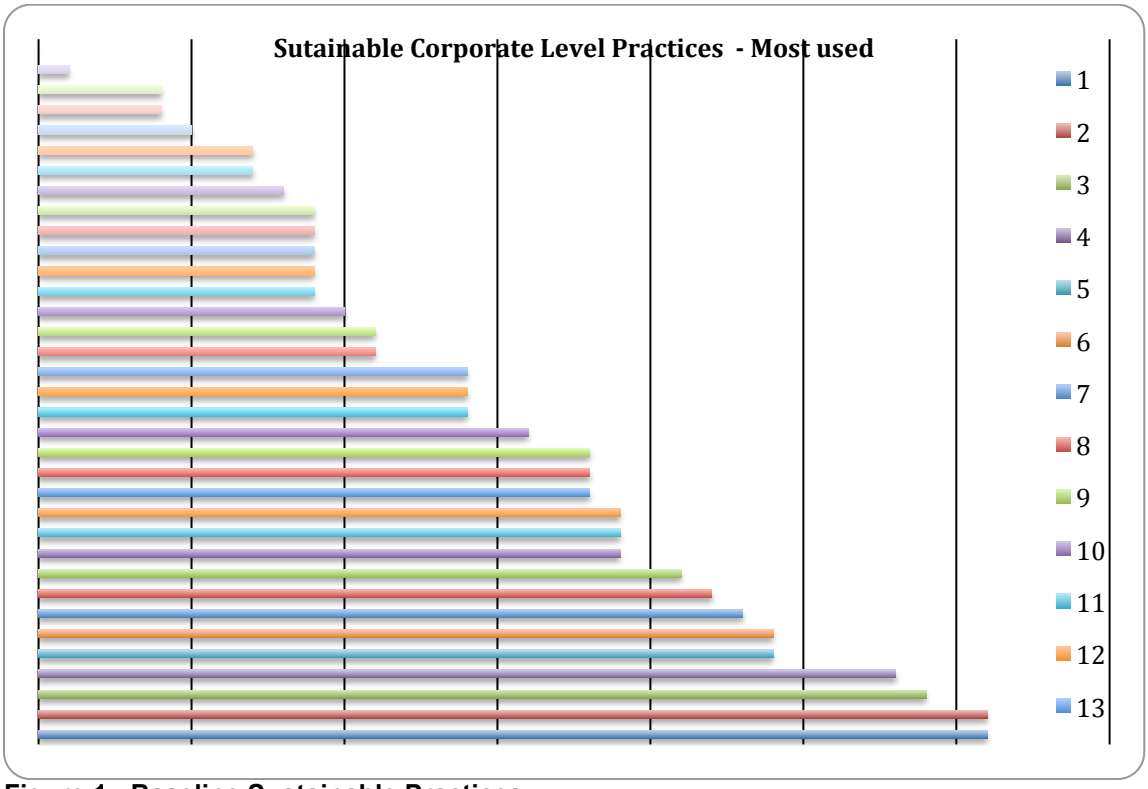


Figure 1 - Baseline Sustainable Practices

Protocol 3 – Baseline Sustainability Best Practices Section 1 Analysis

Results of Protocol 3 Section 1 report that the four most used and least used sustainable practices are as follows:

Most Used Sustainable Practices:

1) A recycling program for office waste
2) A formal process for capturing lessons learned
3) Employees with sustainability expertise
4) Access to external sustainability specialists/partners

Least Used Sustainable Practices:

1) A green travel policy (e.g., environmentally friendly hotels)
2) A green investment program for retirement/pension plans
3) Alternative fuel fleet vehicles
4) A green housekeeping program

Given the nature of the most commonly used practices, this data may suggest that companies are using practices that are the most financially beneficial in general to the company. The use of the a formal process for capturing the lessons learned not only aids in sustainable efforts, but helps save time and money for the company on future projects. This practice is directly linked to the bottom line profit for a company. This data may also suggest that companies are using the easiest practices to initiate their involvement in emerging sustainable policies. The use of recycling programs for office waste is inexpensive and easy to institute, thus increasing the acceptance among all levels of personnel. Additionally, practices 3 and 4 are required among most LEED projects and may be the most widely used due to the desire to win projects.

Conversely, this data may suggest the opposite for the least used practices. All four of these practices represent expensive policies. Each policy could potentially cost the company large sums of money and replace policies that are already useful and widely accepted. The cost to refit a company with alternative fuel fleet vehicles could be large and it does not create a larger net profit margin for the company. Therefore the adoption of this practice could be viewed as counter-productive.

Protocol 3: Baseline Sustainability Best Practices Section 2

Protocol - 3a: Project Management Plans Results

The focus of this section was to determine which Project Management Plan practices each company currently uses at the corporate and project levels that represent sustainability best practices. For each of the practices in the developed checklist, students were asked to either observe directly whether or not it is being used in the company, or ask someone in the company whether it is being used. The project-specific practices in particular required students to work with someone in the company to find out whether or not the practices are used on *other* projects besides the one on which they may be working.

Table 2 - Project Management Plans

Practice	Never tried/not applicable	Tried but abandoned	Use on some projects	Use on all projects	Don't know
Project Management Plans					
1. Sedimentation & Erosion Control Plan	2	0	10	25	0
2. Indoor Air Quality Management Plan	8	0	18	12	0
3. Solid Waste Management Plan	5	1	14	17	1
4. Site Disturbance/Habitat Protection Plan	8	0	19	10	1
5. Safety Plan	1	0	2	34	0
6. Occupant/Tenant Education Plan	7	0	12	18	0
7. Spill Plan/Hazardous Waste Management Plan	5	0	11	21	0

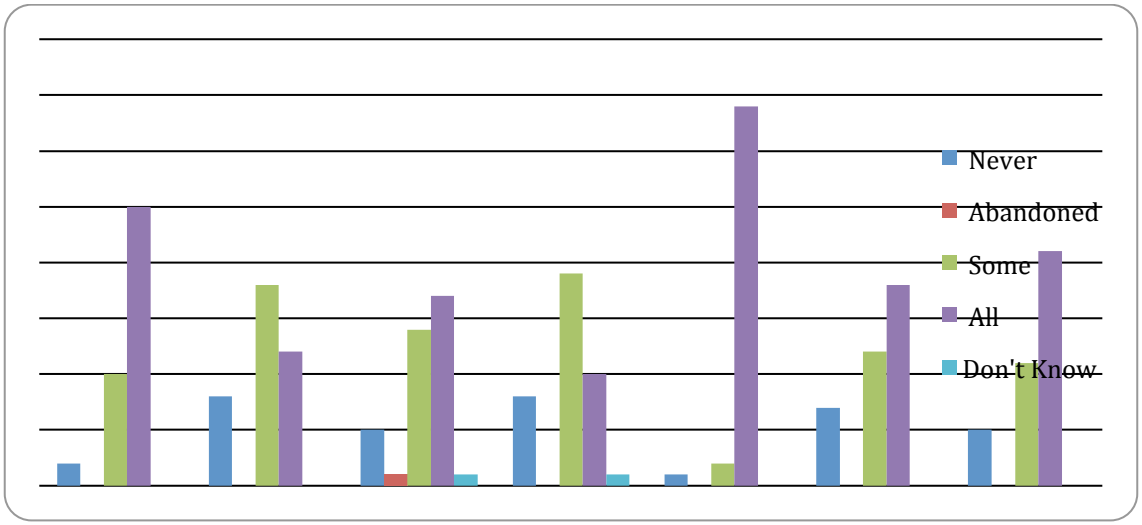


Figure 2 - Project Management Plans

Protocol - 3a: Project Management Plans Analysis

The most commonly used practice is the use of a safety plan, whereas the least used practice is the use of an indoor air quality plan and habitat protection plan. This may suggest that the use of the required practice, or compliance with federal and state regulations, is most widely adopted and the use of the practice that is more complex and expensive is least commonly used because these programs are not required and the original practice is sufficient.

Protocol - 3b: Sustainable Procurement Practices Results

The focus of this section was to determine which Sustainable Procurement Practices each company currently uses at the corporate and project levels that represent sustainability best practices. For each of the practices in the developed checklist, students were asked to either observe directly whether or not it is being used in the company, or ask someone in the company whether it is being used. The project-specific practices in particular required students to work with someone in the company to find out whether or not the practices are used on *other* projects besides the one on which they may be working.

Table 3 - Sustainable Procurement Practices

Practice	Never tried/not applicable	Tried but abandoned	Use on some projects	Use on all projects	Don't know
Sustainable Procurement Practices					
1. Recycled content materials	2	0	29	5	1
2. Products or materials produced locally	3	1	28	5	1
3. Certified sustainably harvested wood products	7	0	23	3	5
4. GreenSeal Certified paints/coatings or doors/windows	9	0	27	1	1
5. GreenLabel certified carpet and floor covering products	9	0	25	2	2
6. Salvaged or reused materials	2	0	28	5	3
7. Rapidly renewable materials	9	1	22	1	5
8. EnergyStar rated products	2	0	31	2	1
9. Takeback clauses with vendors to provide for returning unused or damage products	8	0	16	5	8
10. Reusable packaging returned to vendors	15	0	15	3	4
11. Biodegradable product packaging	15	0	12	0	10
12. Just-in-time product delivery	2	1	26	5	5

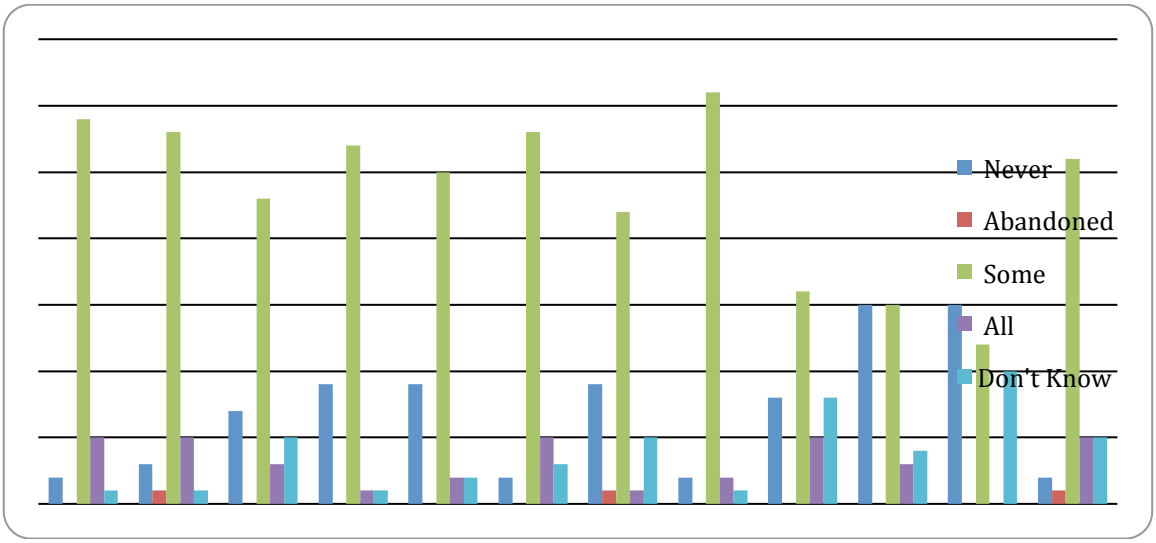


Figure 3 - Sustainable Procurement Practices

Protocol - 3b: Sustainable Procurement Practices Analysis

Section 3b suggests that the most used products are those that are locally produced, made from recycled content, are provided with take back clauses for unused products and are delivered just in time to minimize storage. All of these factors can provide bottom line savings through potentially cheaper materials and less waste and storage. The least used materials are those that have packaging that is returned to vendors, possibly because of the time that is required to return packaging and the cost associated with shipping. The use of biodegradable packages may be used less because it is not under the control of the contractor, or because it remains a fairly unusual practice. This may be a decision made by the manufacturer.

Protocol - 3c: Sustainable Contracting Practices Results

The focus of this section was to determine which Sustainable Contracting Practices each company currently uses at the corporate and project levels that represent sustainability best practices. For each of the practices in the developed checklist, students were asked to either observe directly whether or not it is being used in the company, or ask someone in the company whether it is being used. The project-specific practices in particular required students to work with someone in the company to find out whether or not the practices are used on *other* projects besides the one on which they may be working.

Table 4 - Sustainable Contracting Practices

Practice	Never tried/not applicable	Tried but abandoned	Use on some projects	Use on all projects	Don't know
Sustainable Contracting Practices					
1. Subcontractor selection based on sustainability experience or capabilities	14	1	17	2	2
2. Explicit sustainability goals/requirements in contracts with subcontractors	11	0	21	5	1
3. Incentives or penalties in contracts for meeting sustainable performance goals	15	0	17	4	2
4. Documentation of sustainability experience as part of bids/proposals submitted by company	13	0	18	4	3
5. Online bidding	14	2	17	1	4
6. Subcontractor payment based on square footage of final product instead of total materials to encourage efficient material use	18	0	15	3	3

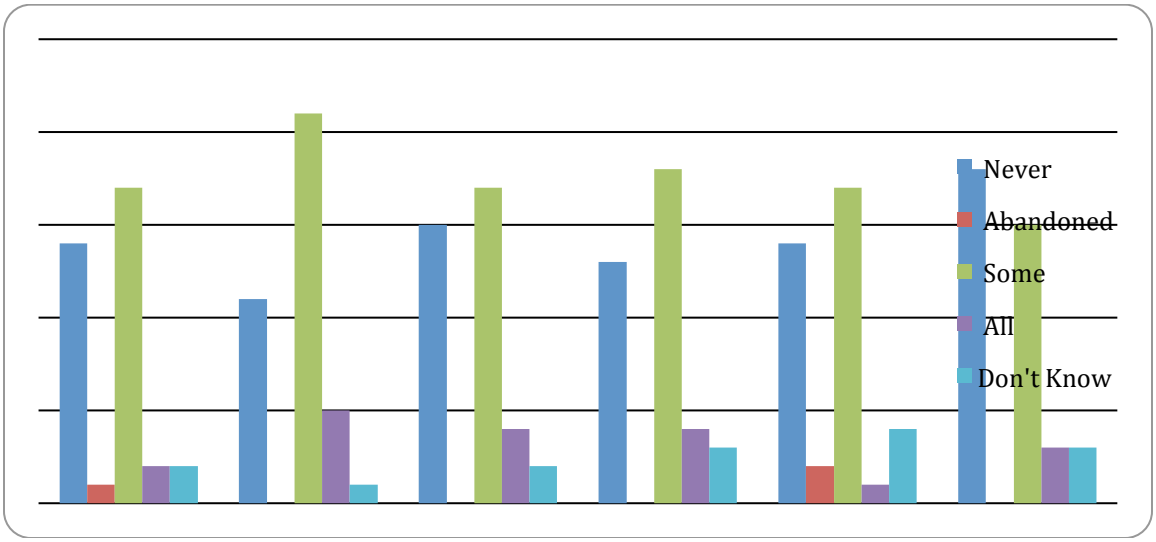


Figure 4 - Sustainable Contracting Practices

Protocol - 3c: Sustainable Contracting Practices Analysis

Section 3c may suggest that each of the contracting styles are unused and on occasion are employed in the contracting for subcontractors. This possibly suggests that these methods are used on owner driven LEED projects and otherwise are not used by contractors to secure subs for their jobs. It may also suggest that there is a large variance among the level of sustainability for the companies represented in this survey, which may be due to the level of requirements in the company's sector of the industry. This may also be a result of owners not knowing about or wanting to institute new practices into their bidding and project processes. Further development of the questions for this portion would help to clarify the results and produce more accurate assumptions.

Protocol - 3d: Temporary Construction Materials Results

The focus of this section was to determine which Temporary Construction Materials each company currently uses at the corporate and project levels that represent sustainability best practices. For each of the practices in the developed checklist, students were asked to either observe directly whether or not it is being used in the company, or ask someone in the company whether it is being used. The project-specific practices in particular required students to work with someone in the company to find out whether or not the practices are used on *other* projects besides the one on which they may be working.

Table 5 - Temporary Construction Materials

Practice	Never tried/not applicable	Tried but abandoned	Use on some projects	Use on all projects	Don't know
Temporary Construction Materials					
1. Bio-based form oil/release agents/dust suppression	7	0	22	2	6
2. Bio-based soil stabilization/erosion control products	9	1	19	2	7
3. Stay-in-place insulating concrete forms	12	3	19	1	3
4. Reusable formwork/shoring/bracing	2	0	27	8	0
5. Recycled paper tube formwork	10	0	21	2	5
6. Recycled plastic rebar supports	12	1	21	2	3
7. Sustainably harvested wood products	7	0	24	1	6
8. Reuse of excavation spoils and topsoil	1	0	26	11	0
9. Formaldehyde-free plywood and engineered wood products	4	1	24	6	3
10. Use of screws and mechanical fasteners instead of nails/adhesives to facilitate reuse	8	1	18	6	5
11. Reuse of temporary electrical equipment and lighting on other jobs	3	0	21	13	1
12. Bio-based cleaning agents	10	0	23	1	4

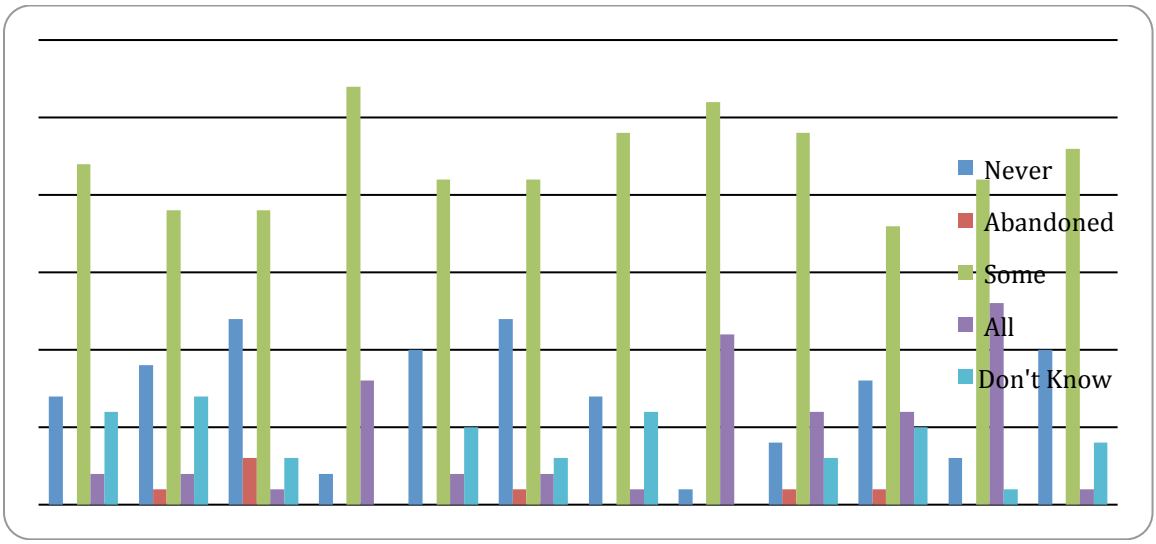


Figure 5 - Temporary Construction Materials

Protocol - 3d: Temporary Construction Materials Analysis

Section 3d seems to suggest that practices with direct cost and time savings are more widely in practice than those that are not. Bio-based cleaning agents are one of the least used practices, whereas the reuse of materials such as electrical equipment and excavation spoils is the most widely used. In comparison, the use of cleaning agents present no major cost or time savings for a contractor, whereas the reuse of materials on other portions of the site or an alternate project may present considerable savings.

Protocol - 3e: Sustainable Site Management Practices Results

The focus of this section was to determine which Sustainable Site Management Practices each company currently uses at the corporate and project levels that represent sustainability best practices. For each of the practices in the developed checklist, students were asked to either observe directly whether or not it is being used in the company, or ask someone in the company whether it is being used. The project-specific practices in particular required students to work with someone in the company to find out whether or not the practices are used on *other* projects besides the one on which they may be working.

Table 6 - Sustainable Site Management Practices

Practice	Never tried/not applicable	Tried but abandoned	Use on some projects	Use on all projects	Don't know
Sustainable Site Management Practices					
1. Tree/vegetation protection measures	2	0	20	15	1
2. Stormwater Best Management Practices/Erosion Control measures	1	0	17	19	0
3. Site disturbance planning for circulation and laydown, e.g., phased development to minimize exposure of bare soil	4	0	19	14	0
4. Ecosystem restoration	8	0	16	6	6
5. Tunneling instead of trenching	12	1	22	1	2
6. Shared trenches for utilities	5	0	31	2	0
7. Site natural resources inventory	14	0	11	3	9
8. Participation in a natural resources or wildlife conservation program	15	0	12	1	10
9. Capture and reuse of on-site water for dust control, e.g., rainwater or process water	18	2	14	1	2
10. Limiting equipment traffic and staging locations to areas that will eventually be paved	6	1	19	10	1
11. Staging of all major equipment on paved surfaces	6	1	26	5	0
12. Selling or donating salvageable plants, shrubs, or trees during site clearing	14	1	17	1	4
13. Minimized slope disturbance	2	0	29	6	1

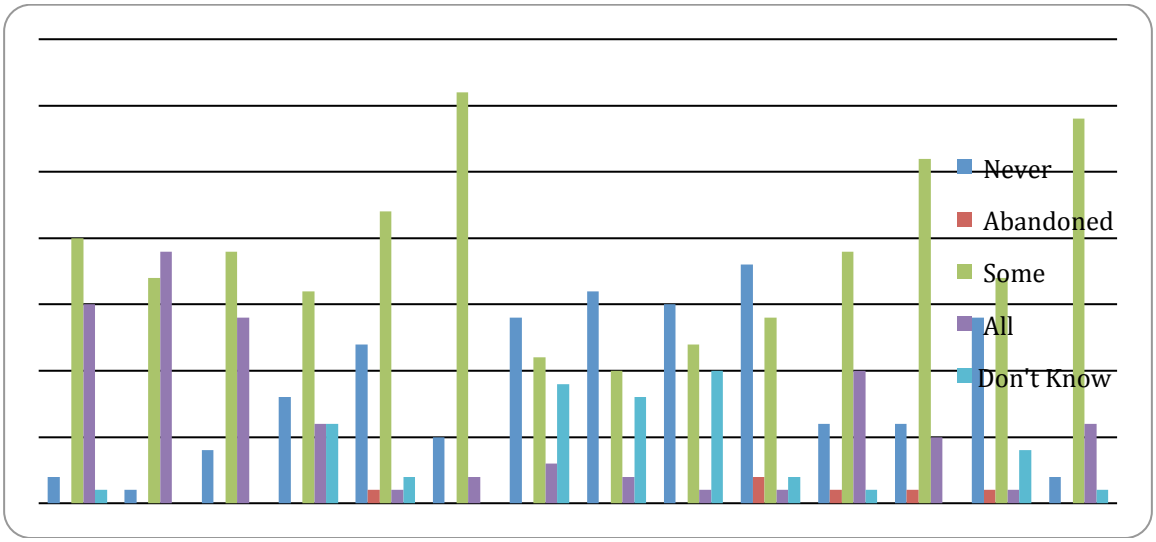


Figure 6 - Sustainable Site Management Practices

Protocol - 3e: Sustainable Site Management Practices Analysis

Section 3e seems to suggest that the more complicated practices are used less. The capturing of on-site water for dust control is the least used practice employed by companies, where as the erosion control procedure is the most used on site. This may be due to the type of erosion control practice used. Silt fences are relatively easy to install and remove whereas the installation of a rainwater collection system is more complex and having a packaged dust control contractor perform this procedure may be more beneficial to the contractor.

Protocol - 3f: Sustainable Project Management Practices Results

The focus of this section was to determine which Sustainable Project Management Practices each company currently uses at the corporate and project levels that represent sustainability best practices. For each of the practices in the developed checklist, students were asked to either observe directly whether or not it is being used in the company, or ask someone in the company whether it is being used. The project-specific practices in particular required students to work with someone in the company to find out whether or not the practices are used on *other* projects besides the one on which they may be working.

Table 7 - Sustainable Project Management Practices

Practice	Never tried/not applicable	Tried but abandoned	Use on some projects	Use on all projects	Don't know
Sustainable Project Management Practices					
1. Sustainability addressed in toolbox meetings	14	1	16	6	1
2. Sustainability issues included in project kickoff meeting	5	1	27	6	0
3. Sustainability champion assigned to project	18	1	15	2	3
4. Constructability analysis of project prior to bid	1	0	18	16	0
5. Participation of constructor in design process	2	0	27	9	0
6. Value engineering or value enhancement process applied to project before construction	2	0	24	11	0
7. Written sustainability mission statement, goals, and team member roles for project	10	1	22	3	2
8. Project-specific sustainability training	13	0	23	1	1
9. Electronic document submittals, e.g., shop drawings, as-built drawings	5	1	22	10	1
10. Electronic document distribution	1	0	21	16	0
11. Bar coding/RFID chips for inventory control or material tracking	21	0	7	4	6
12. Electronic punch lists	8	0	22	6	2

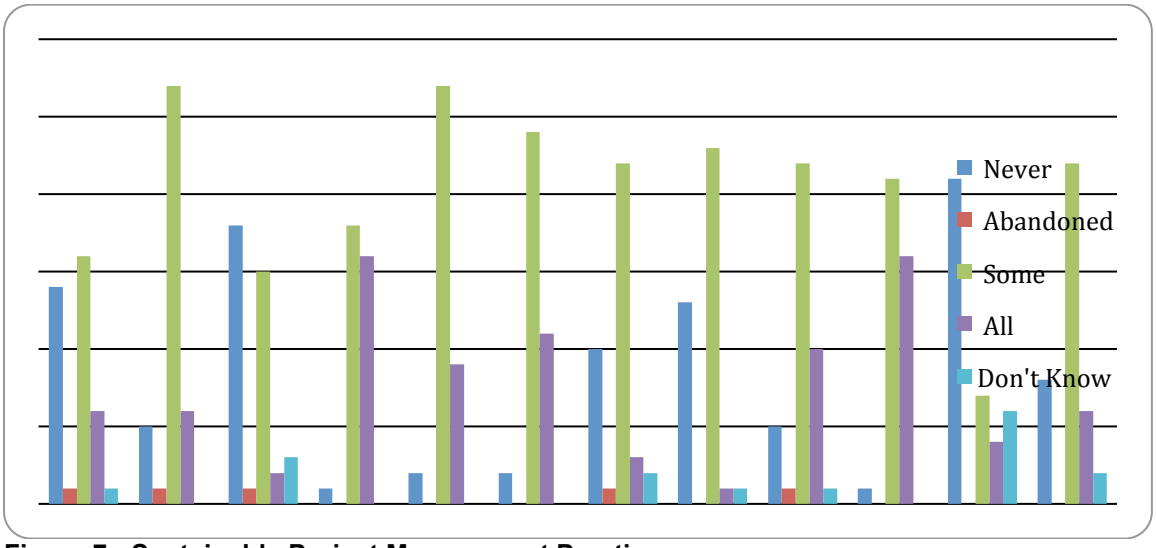


Figure 7 - Sustainable Project Management Practices

Protocol - 3f: Sustainable Project Management Practices Analysis

Section 3f suggests that the more complex practices are again the least employed. The use of bar coding for project inventory control requires large amounts of coordination among subcontractors and a large initial cost to purchase the equipment. This practice may also be project specific and therefore incur a greater cost for adoption. In comparison, constructability reviews and electronic document distribution are company wide practices that are cheaper to adopt due to size. The companies probably perform the constructability review within the pre-bid or post-bid time frame as part of their scheduling, therefore representing less dedicated time to this practice.

Protocol - 3g: Sustainable Audits, Benchmarking, and Metrics Results

The focus of this section was to determine which Sustainable Audits, Benchmarking and Metrics each company currently uses at the corporate and project levels that represent sustainability best practices. For each of the practices in the developed checklist, students were asked to either observe directly whether or not it is being used in the company, or ask someone in the company whether it is being used. The project-specific practices in particular required students to work with someone in the company to find out whether or not the practices are used on *other* projects besides the one on which they may be working.

Table 8 - Sustainable Audits, Benchmarking and Metrics

Practice	Never tried/not applicable	Tried but abandoned	Use on some projects	Use on all projects	Don't know
Sustainable Audits, Benchmarking and Metrics					
1. Use of LEED Rating System	7	1	29	0	1
2. Use of other green project rating systems, e.g., SPiRiT, GreenGlobes, EarthCraft House, other green homes rating systems, etc.	18	1	12	1	7
3. Whole Building Commissioning	9	0	19	7	4
4. Measurement and Verification	7	0	20	9	3
5. Energy auditing/testing	7	0	25	2	3

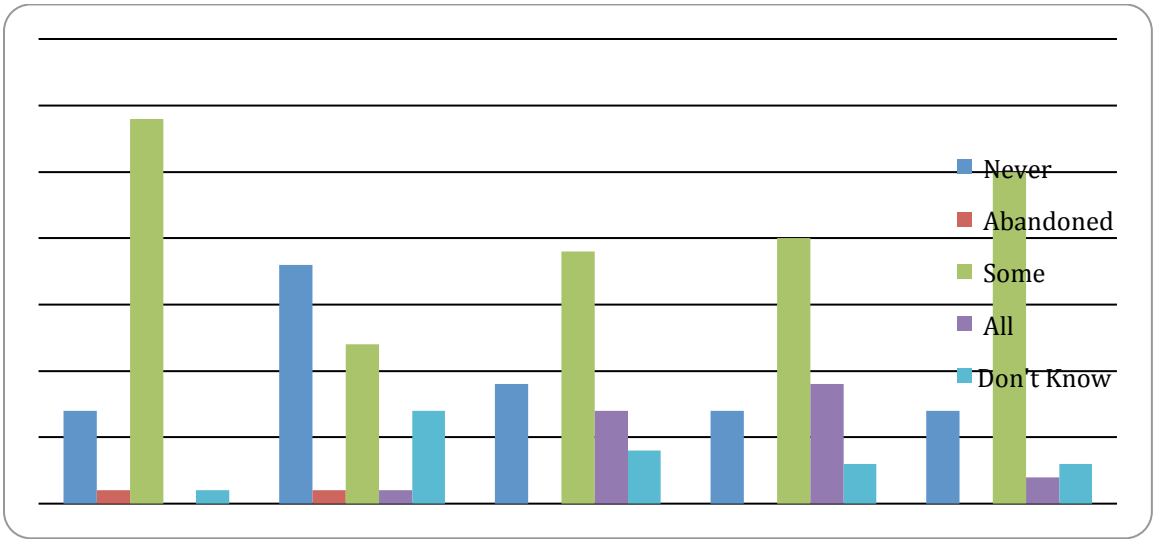


Figure 8 - Sustainable Audits, Benchmarking and Metrics

Protocol - 3g: Sustainable Audits, Benchmarking, and Metrics Analysis

Section 3g seems to suggest that of all the metrics to use on a project for evaluation of sustainability, LEED is the most commonly used. This could be for various reasons including owner request, familiarity or exposure level for public relations. There would need to be further analysis to determine exact reasons for this finding.

Protocol - 3h: Indoor Environmental Quality Management Results

The focus of this section was to determine which Indoor Environmental Quality Management each company currently uses at the corporate and project levels that represent sustainability best practices. For each of the practices in the developed checklist, students were asked to either observe directly whether or not it is being used in the company, or ask someone in the company whether it is being used. The project-specific practices in particular required students to work with someone in the company to find out whether or not the practices are used on *other* projects besides the one on which they may be working.

Table 9 - Indoor Environmental Quality Management

Practice	Never tried/not applicable	Tried but abandoned	Use on some projects	Use on all projects	Don't know
Indoor Environmental Quality Management					
1. No smoking job site	11	1	18	7	0
2. Non-toxic or bio-based cleaning agents for final cleaning activities	7	1	22	4	4
3. Building HVAC flush-out prior to occupancy	6	1	17	12	2
4. Baseline Indoor Air Quality Testing	8	0	23	6	1
5. Protection/isolation of all ductwork during dust-producing activities	5	0	17	15	0
6. Special filters used during construction/filter replacement before occupancy	6	0	15	16	0
7. Low- or no-VOC caulk, adhesives, paints, and sealants	5	2	21	4	5
8. Non-fiberglass containing duct liners	7	1	20	1	8
9. Mold-resistant drywall	4	0	29	5	0
10. Moisture management of stored materials and building systems	5	0	17	14	1
11. Use of waterstops, sealants, vapor barriers, and water barriers at all utility penetrations, construction joints, slab/soil contact areas	2	1	13	22	0
12. Completing building dry-in before installing moisture-sensitive materials and systems	7	0	18	12	1
13. Use of negative air pressure in work areas to reduce transfer of contaminants	9	2	20	3	4
14. Use of walk-off mats inside dust control areas	5	1	27	4	0

Practice	Never tried/not applicable	Tried but abandoned	Use on some projects	Use on all projects	Don't know
15. Locating construction equipment and traffic away from building openings and air intakes	2	1	23	10	2
16. Personal air monitoring systems for workers	17	0	17	2	3

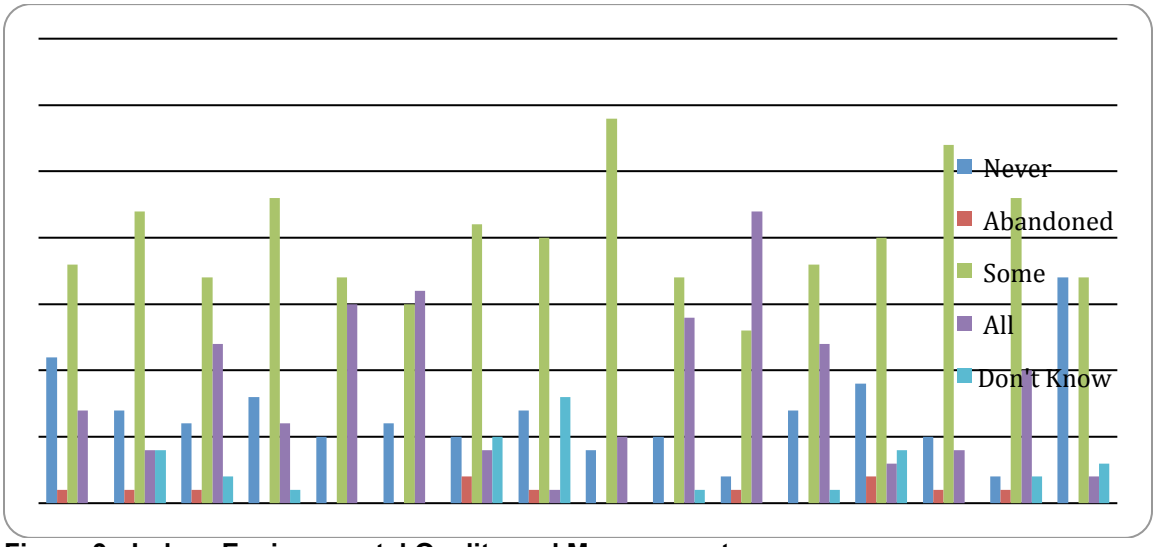


Figure 9 - Indoor Environmental Quality and Management

Protocol - 3h: Indoor Environmental Quality Management Analysis

Section 3h reports the most commonly used practice for indoor environmental quality management is the use of water stops and sealants for utility penetrations. This practice may be widely used to ensure a decrease in rework in the future and in time save the company money by increasing the life cycle of constructed facilities. The least commonly used practice is personal air monitoring systems for workers. This is a costly system and the use of other larger systems to increase air quality may have rendered this procedure not worth the extra cost.

Protocol - 3i: Solid Waste Management Results

The focus of this section was to determine which Solid Waste Management practices each company currently uses at the corporate and project levels that represent sustainability best practices. For each of the practices in the developed checklist, students were asked to either observe directly whether or not it is being used in the company, or ask someone in the company whether it is being used. The project-specific practices in particular required students to work with someone in the company to find out whether or not the practices are used on *other* projects besides the one on which they may be working.

Table 10 - Solid Waste Management

Practice	Never tried/not applicable	Tried but abandoned	Use on some projects	Use on all projects	Don't know
Solid Waste Management					
1. On-site job waste separation	4	0	27	6	1
2. Construction waste recycling	2	0	28	8	0
3. Deconstruction/salvage of existing building components	4	0	30	4	0
4. On-site chipping/shredding/mulching	9	1	23	1	3
5. Precut/prefabricated materials and components	0	0	34	3	1
6. Donation of unused materials or reusable items	9	0	26	0	3
7. Involvement of subcontractors in waste minimization plans	5	0	26	4	3
8. Central cutting area for wood and other materials	11	1	22	2	2
9. Material storage/staging to prevent on-site damage	2	0	22	14	0
10. Recycling of NiCad batteries from portable power tools	7	1	15	7	8
11. First-in, first-out material use policy	8	1	20	2	6

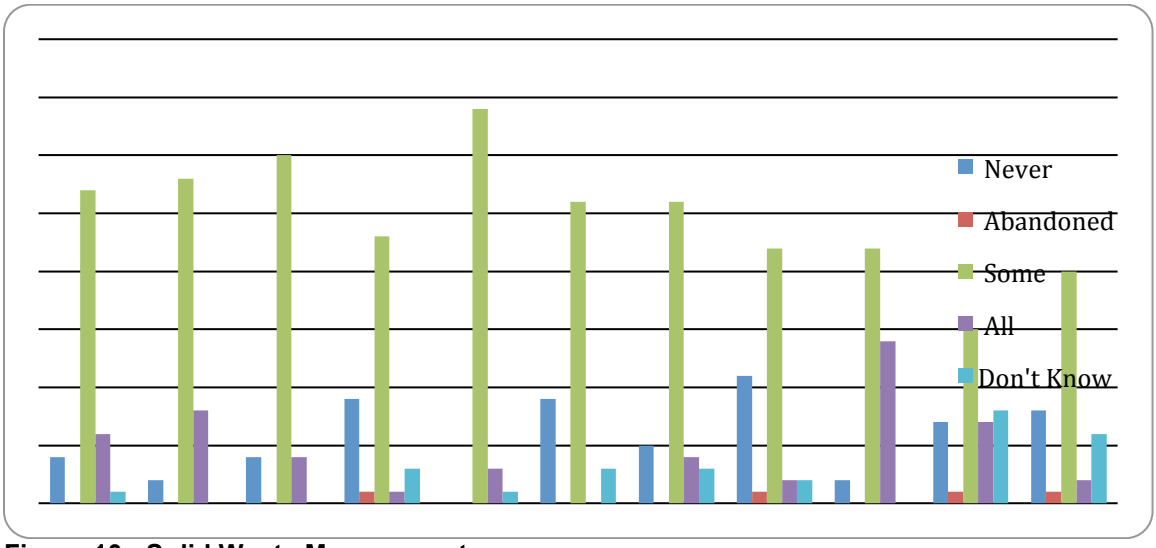


Figure 10 - Solid Waste Management

Protocol - 3i: Solid Waste Management Analysis

Section 3i suggests that the most commonly used solid waste management practice noted was material storage to prevent on-site damage. This practice can be relatively cheap to facilitate, requiring a storage container in most cases. This can directly affect the costs of projects given the varying degree of movement for some materials on site, such as finish work (e.g., door packages). Conversely, the least common practice on site was reported as a centralized area for woodcutting. This practice may be practical in some areas where there is a central area, but may also be considered a waste of time and resources if there is no central area to work from. Given that situation, this practice could be more harmful financially than beneficial.

Protocol - 3j: Energy Best Practices Results

The focus of this section was to determine which Energy Best Practices each company currently uses at the corporate and project levels that represent sustainability best practices. For each of the practices in the developed checklist, students were asked to either observe directly whether or not it is being used in the company, or ask someone in the company whether it is being used. The project-specific practices in particular required students to work with someone in the company to find out whether or not the practices are used on *other* projects besides the one on which they may be working.

Table 11 - Energy Best Practices

Practice	Never tried/not applicable	Tried but abandoned	Use on some projects	Use on all projects	Don't know
Energy Best Practices					
1. Use of photovoltaic power supplies for construction and warning signage	16	0	15	0	6
2. Shutting off temporary lighting when unnecessary or not in use	2	2	23	11	0
3. Proper insulation of all ground-contacting building envelope components	1	0	14	20	2
4. Air sealing of all penetrations between conditioned and unconditioned areas, fixture and junction boxes, and building envelope junctions	4	1	16	14	2
5. Energy efficient framing techniques	3	0	21	8	5
6. Thermal breaks in building envelope	4	0	20	10	3
7. Permanent sealing of all ductwork joints using mastic, not duct tape	4	0	20	12	1
8. Reduced elbows and bends in piping and ductwork to improve flow efficiency	1	0	18	18	0

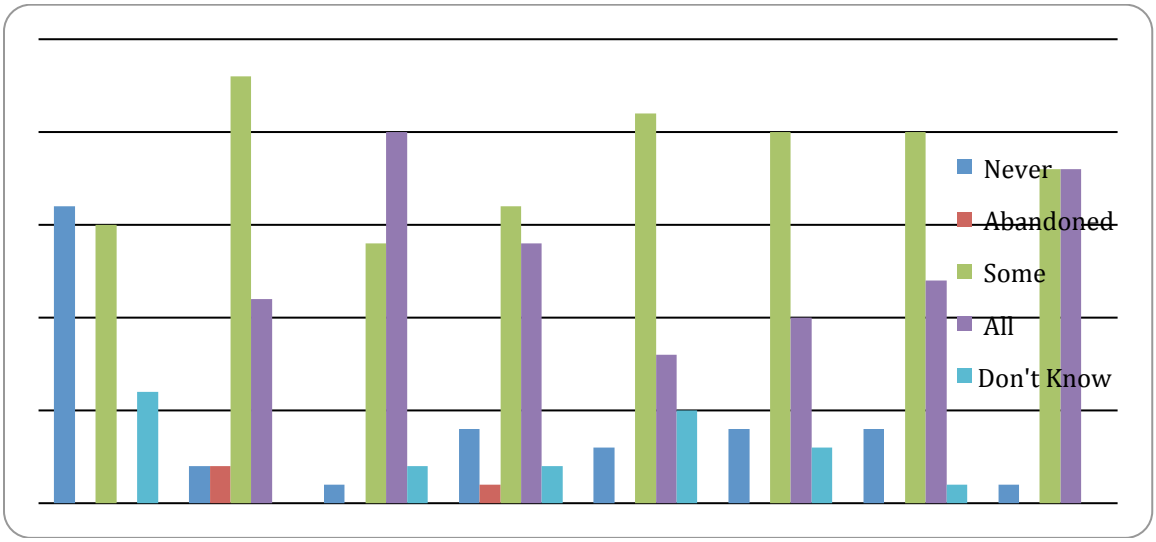


Figure 11 - Energy Best Practices

Protocol - 3j: Energy Best Practices Analysis

Section 3j displays that most contractors are using Energy Best Practices on some jobs and most commonly are using proper insulating techniques on all ground contacting envelope components and reducing the amount of bends in tubing to increase flow. The large numbers reporting using these practices could be a result of increased owner requirements or increased architectural influence on building design. The least common practice reported was the use of Photovoltaic panels. This could be a result of the large initial costs of the system or the complexity of the system from a contractors and owner's vantage point.

Protocol - 3k: Alternative Transportation/Equipment Results

The focus of this section was to determine which Alternative Transportation/Equipment practices each company currently uses at the corporate and project levels that represent sustainability best practices. For each of the practices in the developed checklist, students were asked to either observe directly whether or not it is being used in the company, or ask someone in the company whether it is being used. The project-specific practices in particular required students to work with someone in the company to find out whether or not the practices are used on *other* projects besides the one on which they may be working.

Table 12 - Alternative Transportation/Equipment

Practice	Never tried/not applicable	Tried but abandoned	Use on some projects	Use on all projects	Don't know
Alternative Transportation/Equipment					
Fueling all equipment at a designated refueling station or off-site to minimize spill risk	14	1	10	8	5
Minimizing equipment idling	7	1	17	10	3
Alternative fuel vehicles	27	0	9	1	2
Encouraging alternative transportation to site by workers	15	0	18	3	3

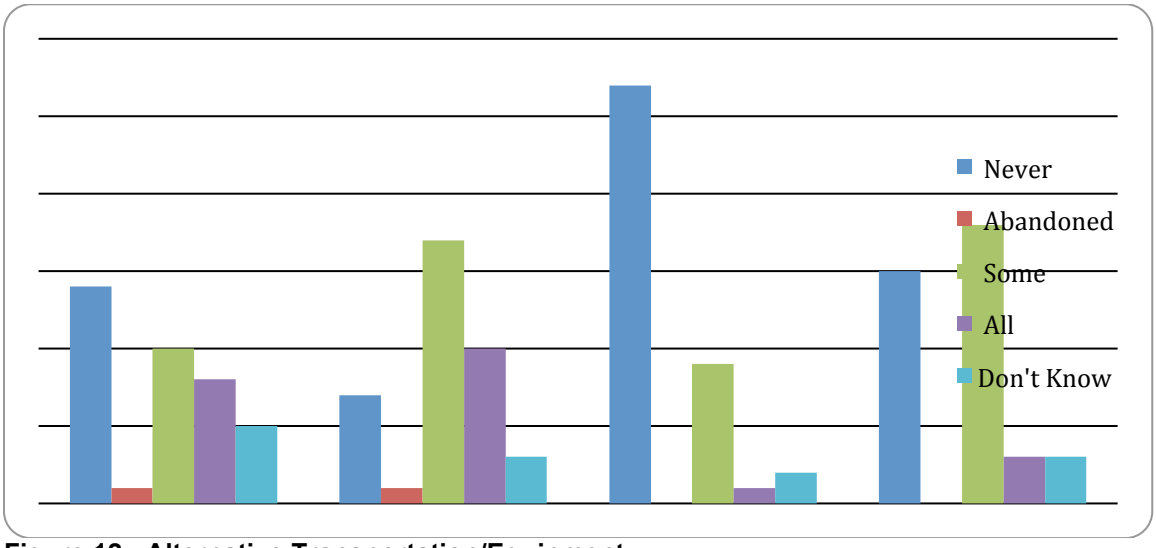


Figure 12 - Alternative Transportation/Equipment

Protocol - 3k: Alternative Transportation/Equipment Analysis

Lastly, section 3k suggests that the most commonly used practice associated with alternative transportation and equipment was reducing equipment idling time. This practice also represents a direct cost savings to the contractor given the price of fuel at the time of this survey. Additionally, less idling of gas powered equipment represents more productivity due to equipment being in use. The least used practice was reported as the purchase and use of alternative fuel vehicles, which could be a direct result of a large initial cost.

Protocol - 3: Baseline Sustainability Best Practices Section 2 - Summary

Based on reported results of Protocol 3 Section 2 for use of each practice across all projects, the four most used and least used sustainable practices among *all* investigated project-level best practices are as follows:

Most Used Sustainable Practices:

1) Use of a Safety Plan
2) Sediment and Erosion Control Plan
3) Use of water stops, sealants, vapor barriers and water barriers at all utility penetrations, construction joints, and slab/soil contact areas.

Least Used Sustainable Practices:

1) Biodegradable Product Packaging
2) LEED Rating System (although there were 29 responses for "use on some projects")
3) Donation of unused materials or reusable items (26 responses for "use on some projects")

Given the nature of the most commonly used practices, this data may suggest that companies are using practices that are the most financially beneficial in general to the company. The use of a safety plan, and sediment and erosion control plans are fairly common practices that are in use for most construction projects. The absence of a safety plan can not only inhibit a contractor form obtaining work, but also indirectly results in large fines from regulatory organizations, such as OSHA (Occupational Safety and Health Administration). Additionally, the use of sediment and erosion control plans and water stops and sealants are fairly common practices that are required by most contracts and if ignored could be costly to the contractor later in the construction process.

Conversely, the least used practices may have the opposite impact on a contractor's business. Biodegradable packaging, donating unused materials and even use of a LEED rating system may represent costly practices to the contractor if implemented. The variable for the LEED rating system, in comparison to the other two practices mentioned in this summary, is that failure to use the LEED rating system can prevent the contractor from obtaining work and is even becoming mandatory in some areas.

Protocol 4 – Understanding Adoption of Sustainability Best Practices

This next protocol investigated the experiences and reasons behind the company's experiences with best practices that it has tried. The work on this protocol was based on the findings from Protocol 3, which established an inventory of sustainability best practices employed by the company.

For this exercise, students were tasked to select three practices from the last survey that their company presently uses on some or all of its projects or has tried in the past but abandoned. They were instructed to locate one or more people to interview who have had direct experience with the development or implementation of each practice.

Protocol 4 – Understanding Adoption of Sustainability Best Practices Results

The questions in Protocol 4 aim to understand the reasons why some practices are used and why others are not. Certain questions were omitted from this report to maintain confidentiality. Additionally, some answers were modified to expedite the sorting process. These answers are noted in the report below. Note that the practices studied here were selected by each individual student, with no specified criteria other than that the practice had to be used at one point or another by the company being studied. Individual reasoning behind the selection of one practice over another was not solicited.

- **Which best practice did you choose to investigate?**

Use of LEED Rating System	7
Sedimentation and Erosion Control Plan	7
Special filters used during construction/filter replacement before occupancy.	1
Safety Plan	8
Construction Waste Recycling	2
Electronic document submittals	3
Participation of constructor in design process	2
Reusable Formwork and Concrete Materials	1
First in, First out material use policy	1
Encouraging alternative transportation to site by workers	1
Reusable formwork/shoring/bracing	1

Waste Management - Recycling Materials	1
Use of Certified Wood - MR Credit 7	1
Energy Star rated products	2
Reuse of temporary electrical equipment and lighting on other jobs	2
Mold Resistant Drywall	2
Just-in-time product delivery	1
Precut/prefabricated materials and components	1
Enclosure/isolation of dust-producing activities	1
Tree/vegetation protection measures	2
Indoor Air Quality Management Plan	1
Whole Building Commissioning	2
Video Conferencing instead of travel	1
On-site job waste separation / construction waste recycling	1
Value engineering or value enhancement process applied to project before construction	2
Constructability analysis of project prior to bid	1
Solid Waste Management Plan	2
Green Seal Certified paints/ coatings or doors/ windows	1
Ecosystem Restoration	1
Use of negative air pressure in work areas to reduce transfer of contaminants	1
Moisture Management of stored materials and building systems	1
Locating construction equipment and traffic away from building openings and air intakes	1
A formal process for capturing lessons learned	2
A recycling program for office waste	1
Stay-in-place insulating concrete forms	2
Completely building dry-in before installing moisture-sensitive materials and systems	1
Take back clauses	1
Non smoking job sites	3
Reuse of demolished concrete as backfill, road base, or aggregate	1
Use of other green project rating systems, e.g., SPiRiT, GreenGlobes, EarthCraft House, other green homes rating systems, etc.	1
Green Teams or Sustainability Working Groups	1
a program for revising resources	2
an annual environmental report to stakeholders	1
Use of Walk-Off Mats Inside Dust Control Areas	1
Special filters used during construction/filter replacement before occupancy	1
Indoor Environmental Quality Control Management	3
Use of screws and mechanical fasteners instead of nails/adhesives to facilitate reuse	1
Reusable temporary barriers	1
On-site job waste separation	2
Deconstruction/salvage of existing building components	1
Participation of Constructor in Design Process	1
Reuse of Excavation Spoils and Topsoil	1
Explicit sustainability goals/requirements in Statement of Work/Request for Proposal for subcontractors	1

Site Disturbance Planning	1
Material Storage	1
Use of water stops. Sealants, vapor barriers, and water barriers at all utility penetrations, construction joints, slab/soil contact areas	1
Sustainability addressed in toolbox meetings	1
Constructability analysis of project prior to bid	1
Energy Star rated products	1
Spill/ Hazardous Waste Management Plan	1

- **Who did you interview to obtain your information about this practice?**

Superintendent	16
Project Manager	41
Vice President/Executive	24
Project Engineer	7
Other	30

- **Which of the following best describes your company's use of this practice?**

Use the practice on some projects/in some offices	54
Use the practice on all projects/throughout the company	58
Have tried the practice in the past, but no longer use it	4

- **How did the company initially learn about the practice?**

Requirements	32
Relationships with other organizations/companies	44
"Common Sense" and "Common Practice"	22
Need	13
Other	3

- **When did the company initially learn about the practice?**

Last 5 years	13
Last 10 years	21
Last 10 Years or more	41
Inception	21
Other	5

- **What potential benefits motivated the company to try the practice?**

Cost Savings	46

Client Satisfaction/Requirement	23
Social Responsibility	24
Increase Production/Efficiency	13
Other	8

- **Were there any other motivations involved, e.g., expectations of future regulations, desire to stay on the leading edge, etc.?**

No	33
Cost Savings	21
Client Satisfaction/Requirement	9
Social Responsibility	13
Public Relations/Marketing	20
Other	16

- **Who was the original champion of the practice?**

Owner	25
Vice President/Department Manager	16
LEED Champion/Sustainable Committee	3
Project Manager/Superintendent	19
Unknown	41

- **When did the company initially try the practice?**

Last 5 years	22
Last 10 years	22
Last 10 Years or more	30
Inception (beginning of the company)	13
Other	28

- **In what context did the company initially try the practice?**

Single Project	37
Multiple Projects	38

- **How did the practice require the company itself to change?**
  - Typical answers included:
    - **“**No major changes”
    - **“**No change needed.”
  - Atypical answers included:

- **"**A new way of thinking and documentation. PM's and superintendents had to make sure that they got every point that they set out for."
- **"**Indirectly by encouraging more environmentally friendly building."

- **Who was responsible for the success of the practice?**

Upper Management (CEO, VP, Dept. Director)	34
Field Management (PM, Superintendent)	40
Combination of the entire company	19
Other (unknown, undecipherable)	21

- **What costs were associated with implementation?**

Initial Cost	68
Minimal or No Cost	39
Other	9

- **Did the company have any relationships or agreements with vendors or suppliers that allowed them to try the practice before committing to full-scale implementation?**

No	67
YES	31
Other	18

- **Were any stakeholders resistant to implementation? If so, who was resistant, why were they resistant, and how was this resistance overcome?**

No	89
Upper Management (CEO, VP, Dept. Director)	8
Field Management (PM, Superintendent)	10
Other	2

  - Typical answers included:
    - "I'm sure that there was some hesitation, because it is more work, and documentation, but the owners want something and they will have to pay for it."
    - "Yes – the older generation of turner employees were resistant due to the learning curve, the legal issues with online signing and distribution, some cases it was overcome and some cases it wasn't."
  - Atypical answers included:
    - "(Principal) was resistant from the beginning."

- "Installers and if they want to use our dumpsters they had to separate carpet scraps and padding remains."

- **What outcomes and benefits were realized as a result of implementation?**

Positive Outcomes	105
Negative Outcomes	7
Other	7

- **Were their any unanticipated impacts or side effects of trying the practice that were not originally planned for?**

No	54
Positive	16
Negative	41
Other	5

NOTE: Answers were generalized for ease of analysis.

- **What decision was made regarding whether to continue using the practice, and why?**

Continue	108
Discontinue	7
Other	5

- **Who made the decision regarding whether to continue with the practice, and what evidence was used to support the decision?**

Upper Management (CEO, VP, Dept. Director)	57
Field Management (PM, Superintendent)	12
Required	4
Company as a Whole	12
Other	29

- **If the practice was initially implemented on a small scale, describe the process undertaken to scale it up to other projects or offices.**

N/A (no expansion)	57
Incrementally Scaled up	37
Use of resources (training, money, materials)	9
Other	9

- **What lessons from the initial trial of the best practice were learned that affected how it was deployed on subsequent projects or in subsequent situations?**
    - Typical answers included:
        - **"**The product worked well."
        - **"**They learned that they could cut down on costly mistakes."
    - Atypical answers included:
        - **"**Still being evaluated."
        - **"**Sometimes recycling makes sense, sometimes it does not. Decided on a project by project basis."

- **Has deployment of this best practice led to other changes or practices being implemented? If so, what and why?**

No	51

    - Atypical answers included:
        - **"**Better environmental practices in general of subcontractors"
        - **"**They look forward to expanding this practice to every job site"

- **Please list any additional comments or information you obtained about the practice during the interview.**
    - Typical answers included:
        - **"**I found it interesting that the barriers could be so light when emptied and how much they benefit the environment by using something as simple as water to provide the same purpose as a solid heavy rubber or plastic." (Reusable Temporary Barriers)
        - **"**Most employees like the practice because it allows them to write their opinion and explain how certain things can be changed to benefit the company." (A formal Process for capturing lessons learned)
    - Atypical answers included:
        - **"**Construction waste recycling will likely grow in use, despite a focus on first cost and a lack of dedication. However, economics will almost always be the deciding factor in any practice, perceived or otherwise." (Construction Waste Recycling)
        - **"**I understand that eye protection was not part of Survey #3 directly, but I felt that it tied into the Safety Plan and offered a good discussion on how the company is adopting sustainability practices. I also realized that they are always learning and trying to be the best and most responsible construction company out there." (Safety Plan)

Protocol 4 - Understanding Adoption of Sustainability Best Practices Analysis

Protocol 4 investigates specific practices that each intern chose to pursue in further detail. Based on the results of this protocol, the most commonly chosen practices were the presence of a safety plan, followed closely by the use of LEED rating system and sedimentation control plan. Most companies seem to learn about these practices through connections with other organizations and relationships with other companies and have known about them within the last decade. Of all the practices listed, 40% were used to initiate some sort of cost savings to the company instituting the practice. These companies also reported that 29% , of all respondents, used these practices for no other reason except cost savings, including maintaining an “edge” on the market and social responsibility.

To initiate these practices, half of the companies started on single projects and half were initiated on multiple projects. This data could be interpreted in various ways considering that many of these practices are companywide initiatives and some are project specific. After the practices were initiated and evaluated, the companies reported over 58% of costs associated with them were initial costs and that 88% had positive results. These evaluations resulted in 90% of the practices being continued on other projects within the company.

Protocol 5 – Recommending New Best Practices

In the final assignment students were asked to investigate three best practices *not* currently used by their company and make recommendations to their company regarding implementing those practices. Students were required to present their recommendations to one or more decision makers at the company, and record their responses to the proposal.

Protocol 5 – Recommending New Best Practices Results

The following results for protocol 5 deal with a company's tolerance of new ideas presented by the interns. These questions are asked to probe the reasons why or why not a company would be willing to try new practices. Certain questions were omitted from this report to maintain confidentiality. Additionally, some answers were modified to expedite the sorting process. These answers are noted in the report below.

- **Which best practice are you proposing?**

Recycled Content Materials On-site	1
Bar Coding	1
Alternative Fueled Vehicles	2
Bio-Based Cleaning Agents	1
Sustainability Addressed in Toolbox Meetings	1
Donation of Unused Materials or Reusable Items	2
Stay-in-place Insulating Concrete Forms	2
Construction Waste Management	1
Energy Efficient Framing Techniques	1
Paperless Operations	2
Teleconference	3
The use of mechanical fasteners instead of nails/adhesives to facilitate reuse	1
A recycling program for office wastes	2
On-site Job waste separation	1
Staging of all major equipment on paved surfaces	1
Electronic Punch list	1
Salvaged or reused materials	1
Website/Newsletter on sustainability	1
Electronic document distribution	2
Donation of unused materials or reusable items	2
Indoor Air Quality Management Plan	1
Online Bidding	3

Use of other green project rating systems	2
Use of bar coding/ RFID chips for inventory control and material tracking	1
Rapidly renewable materials	2
Special Filters during construction/filter replacement before occupancy	1
Certified sustainably harvested wood products	1
Protection/isolation of all ductwork during dust-producing activities	1
Training program that includes sustainability and social/environmental issues	1
Reusable packaging returned to vendors	2
Central cutting area for wood and other materials	1
Listings in Major green guides/directories for our services	1
Bicycle facilities/ car pool incentives	2
Personal Air-monitoring systems for workers	1
Capture and Reuse of On-Site Water for Dust Control	3
Use of photovoltaic power supplies for construction and warning signage	1
Incentives or penalties in contracts for meeting sustainable performance goals	1
Participation in a natural resource or wildlife conservation program	1
Non-toxic or bio-based cleaning agents for final cleaning activities	1
Energy Star Rated Products	1
The use of Green Seal Certified paints	2
Technical Information on our Green practices	1
Assign sustainability champions to each project	2
Selling or donating salvageable plants, shrubs, or trees during site clearing	1
Participation of the Constructor in design	1
Products or Materials Produced Locally	2
Recycled rubber/plastic temporary barriers	1
Whole Building Commissioning	1
Shutting off temporary lighting when unnecessary or not in use	1
Environmental Code of Conduct	1
Reusable Formwork/Shoring/Bracing	1
First in, First out method	1

- **What expectations did you have before your interview(s) about how receptive your company would be to your proposal?**

Receptive	56
Not receptive	19
Unsure	7
Other	3

- **Who did you interview to obtain reactions to your proposal?**

Superintendent	8
Project Manager	44
Vice President/Executive	20
Project Engineer	9
Other	4

- **Were the people you interviewed already familiar with the best practice being proposed or was it new to them?**

Familiar	77
Unfamiliar	7
Other	3

- **What questions did the people you interviewed have about your brief? Did they want information beyond what you provided them? If so, what did they want to know?**

None	20
Other	4

  - Typical answers included:
    - **"**How much money exactly this would save the company."
  - Atypical answers included:
    - **"**He asked me to describe the practice in more detail and for resources he could use to research the idea."

- **Why do they think the company has not already implemented the practice?**
  - Typical answers included:
    - "He feels that their current method of formwork is adequate, efficient, and inexpensive."
    - **"**It is too time consuming and more expensive."
  - Atypical answers included:
    - **"**She did not think that the company was aware of the policy."
    - **"**Had not thought about it."

- **What feedback do they have about the information presented to them in your brief? Do they think it's accurate, or would they suggest any changes?**

Accurate and Informative	72
Uninformative	2
Other	14

- **What challenges do they think would be associated with implementing this practice within the company?**
    - Typical answers included:
        - **“**Fighting the costs and learning curve for the first two.”
    - Atypical answers included:
        - **“**No challenges”

- **Would anyone within the company be opposed to implementing the practice? If so, who? What arguments would they raise, and what kinds of evidence would be required to convince them?**

For the practice	34
Against the practice	43
Other	7

- **How would they recommend moving forward with implementation**
    - Typical answers included:
        - **“**They recommend keeping the current program.” (Bicycle Facilities/ car pool incentives)
        - **“**He said that something like this might happen more in the future. But for now, he didn't see this practice being implemented anytime soon.” (Alternative Fuel Vehicles)
    - Atypical answers included:
        - **“**They recommended implementing on a small scale first. Purchasing for one job and trying it out.” (Use of photovoltaic power supplies for construction and warning signage)
        - **“**Implement a company wide policy” (Environmental Code of Conduct)

- **How successful do they think implementation of this practice will be with the company? Why?**
    - Typical answers included:
        - **“**Not very successful.” (Staging of all major equipment on paved surfaces)
        - “Not very, it is used a little bit but it would not be economical to implement this for all their items.” (Products or Materials Produced Locally)
    - Atypical answers included:
        - **“**Successful if first cost proves justified” (EnergyStar Rated Products)
        - **“**Could be successful, but that it wouldn't make much difference, and might return to paper” (Electronic Punchlists)

- **How did your company’s response to your proposal match your expectations?**

Met expectations	67

Did not meet expectations	5
Exceeded expectations	9
Other	4

- **What went well about your experience in making a recommendation to your company?**
  - Typical answers included:
    - **"**I understood more about how my company works, who to go to, what to bring with me, and how to do a proposal."
    - **"**My supervisor liked the idea and said that it would benefit the company and the environment."
  - Atypical answers included:
    - **"**He had some great constructive criticism"
    - **"**I work very closely with the interviewee and had a good idea of what his concerns would be."

- **What would you do differently if you had another chance to make the proposal?**

Nothing	27
Pick a different topic	32
Provide more information	12
Other	9

Protocol 5 - Recommending New Best Practices Analysis

Protocol 5 attempted to gauge the willingness of the companies to receive various proposals for diffusing new sustainable practices into the companies. The results of this attempt were that most of the participants were receptive to the ideas. The majority of the personnel interviewed were project managers and (89%) reported being familiar with the practice before the presentation occurred. With a large portion of the participants possessing an understanding of the practice, they could judge the accuracy of the presentations well and reported that (84%) felt they were accurate and informative.

Once the presentations were given, the reaction among the participants was split evenly among those for and against the practice being employed by the company. The most common reasons for those against a particular practice were reported as financial reasons and wanting to know more about resource allocation and specifics of that particular practice. 79% of the presenters reported their expectations being met by the reactions of the people interviewed; however, 40% would have chosen a different topic.

Future Work

Addressing this inquiry from a macro standpoint, the protocols used in the study have been administered with a large scope and could be narrowed to focus more on the most commonly and uncommonly used practices to gauge a more accurate reasoning for adoption. This focus would address two main issues. First the general assumptions and suggestions could become more specific and accurate and the time period of this research could be updated. This report was administered during the summer of 2007. The economy and industry have since changed drastically and the assumptions of financial constraints on adoption could be further supported or refuted based on the current economic climate.

Approaching this survey from an academic standpoint, the material and questions asked produced an encompassing view of the industry with which Virginia Polytechnic Institute and State University primarily deals. Each protocol dealt with a wide range of questions addressing each company's positions in the industry and which practices they choose to employ. Further development of this study could include more concise questions focusing on themes noticed in this survey. This research could reduce the elements of suspicion in the analysis of this data and help to uncover more concrete reasons for adoption and innovations of sustainable practices.

Additionally, once the data was collected, there were issues compiling the results into succinct and organized sections. The data was initially separated by protocol creating clear categories for the results to be displayed. The problem occurred when, inside these protocols, the results were too vast to condense into concise graphs and charts for reporting. In future studies, this may be avoided by reducing the amount of open-ended questions. This may also be advantageous because this preliminary survey has provided a baseline for future research and as a result the answers to why are already suggested. The next step may be to take these suggested answers and present the participants with multiple-choice questions and allow them to interpret where their answer fits instead of letting the students create their own responses.

Lessons Learned

This study provides a step toward understanding what practices are currently being used in the industry as well as why the companies have chosen to use those particular practices. The aim of this study is to represent a broad cross section of where the industry stands, and although the goal has been met, there is always room to improve. The participants in the study were asked to provide feedback in a debrief session. The results of this meeting are as follows:

The students were asked to provide feedback about each protocol and identify areas of improvement. Examples of positive comments received from students included:

- *"The president of the company learned a little about me and he taught me to be professional."*
- *"Learned how hard it is to be innovative in construction."*
- *"Forced me to realize what a leader in my company is..."*
- *"Met the president of the company and learned how the company got started."*
- *"I now understand the corporate attitude toward sustainability practices."*
- *"I learned about LEED and the sustainability practices we already had."*
- *"I learned how I could help to improve the current sustainability practices."*
- *"I have improved my interviewing and discussion skills."*
- *"Learned from my own research"*
- *"My bosses history made me feel better about doing "grunt work" on site."*

Suggestions for improvements of the protocols from the students included:

- *"Provide the surveys to us up front."*
- *"Avoid excess and repetitive questions."*
- *"Develop more activities we can do outside of work so I don't use so much of my work time."*
- *"Provide us some flexibility to ask other questions during the interviews."*
- *"Ask more reasonable questions relating to most construction sites."*
- *"Steer away from sustainability for at least one assignment, please!"*
- *"Three sustainability practices was too many. My superintendent began to get impatient during the interview."*

Students were also asked to provide general feedback regarding the entire process; below are some of their comments:

- *"Thank you for trying. I feel like I got more out of it than I would have if it were still structured the same."*
- *"I felt confident that I was learning something relevant to the company and the industry by having to do outside research on my own time."*
- *"Please post all the assignments at the beginning of the semester."*
- *"Most companies are not as environmentally friendly as you expect."*

The last area students were asked to comment upon was the Blackboard discussion board postings that were required upon completion of each protocol. Overall, twenty-eight students found the postings useful in sharing ideas and learning from other students, while four students did not find the postings useful. Some of the student comments are provided below:

- *"Allowed me to see how everyone is doing throughout the summer."*
- *"Allowed me a medium to express my questions, concerns and opinions to others and the instructors in an electronic classroom setting."*
- *"This was the most helpful part to see what others were doing."*
- *"I learned from other responses and agreed with some of them."*
- *"I actually read a lot of the posts and commented on them as well."*
- *"I did not find the posts useful in sharing information, but more with posting concerns and how the interviews went."*
- *"I found this not worth my time because it seemed just like another burden on me for the assignments."*

Methodological Recommendations

To further investigate the implications of this study, changes may need to be made to the overall methodology. Placing constraints on the undergraduates that are allowed to participate in this study may lessen the possibility of biased results for this method of data collection. These constraints may consist of level of education or level of work experience in the industry. The results for protocols 1-5 were informative and valid, but the concern is that the students who interviewed the companies may not have had a significant amount of exposure or maturity to gather sufficient data that could prove to be more credible. The constraints placed on these students would limit them to a higher level of education, either Junior or Senior, in the hopes that they would place more effort and importance in soliciting concise and detailed responses form their interviewees. Additionally, prior work experience would also be a way to ensure that the students were

on an appropriate level to engage in a detailed and informative conversation with the interviewees.

Furthermore, this study could be expanded to include, and maybe limited to, graduate students. To be more specific, Virginia Tech University requires all graduate students to participate in a executive shadowing experience during their spring semester. Integrating this survey into that experience would allow for students who have the appropriate level of curriculum and desire to learn from industry professionals to collect data that was more secure and undisputable from the onset of the survey. This integration would also allow the students to have a standard way of initiating a relationship with their assigned executive. These graduate students could be given an intro course to the process that was desired and the expected outcomes. Hopefully, this would encourage more accurate and detailed reporting and increase the thoughtfulness and effectiveness of the survey feedback sessions.

Conclusions

The data reported suggests a large portion of companies in this survey maintain a knowledge base of sustainable practices that cover a wide range of systems. These systems range from using a LEED rating system on projects to introducing new data transfer systems on a company wide scale. This demonstrates awareness by the industry about the current state of technologies and practices available. The data suggests that there are a wide variety of practices and technologies that are not being used and may be the result of many different reasons, many of which are intertwined producing more complicated solutions. Themes in the data reported seem to point towards the cost as a major contributing factor to adoption rate, as well as complexity. To determine a more definitive answer, further research must be conducted that is more directed at why the adoption rate is low and then more efforts can be invested to correct the problems.

References

Ahn, Y.H. and Pearce, A.R. (2007). “Green Construction: Contractor Experiences, Expectations, and Perceptions,” *Journal of Green Building,* 2(3), 106-122.

Ahn, Y.H. and Pearce, A.R. (2009). "Green Construction: U.S. Contractors' Status and Perceptions," *Proceedings of the International Conference on Construction Engineering and Management/Project Management (ICCEM-ICCPM 2009).* Jeju, Korea, May 27-30.

Crew, W. (2006). “CII Best Practices Class”, Virginia Polytechnic Institute and State University, Fall Semester, Nov. 1, 2006, Blacksburg, VA.

DuBose, J.R., Bosch, S.J., and Pearce, A.R. (2007). “Analysis of Statewide Green Building Policies,” *Journal of Green Building,* 2(2), 161-177.

Eisenberg, M., and Berkowitz, R. (1990). *Information problem solving: The Big Six skills approach to library & information skills instruction*. Ablex, Norwood, NJ.

Field Guide for Sustainable Construction. Department of Defense – Pentagon Renovation and Construction Office. (2004). PDF, 2.6 MB, 312 pgs. Available for download at: http://www.google.com/search?hl=en&client=firefox-a&rls=org.mozilla:enUS:official&hs=yKh&ei=cNPgSYICyeqVB7fvrOAO&sa=X&oi=spell&resnum=0&ct=result&cd=1&q=sustainable+field+guide&spell=1

Kanfer, R. (1990). “Motivation theory and industrial and organizational psychology”. In M.D. Dunnette & L.M. Hough (eds), *Handbook of Industrial and Organizational Psychology*. Consulting Psychologists, Palo Alto, CA 75-170.

Kanungo, R.N. & Menon, S.T. (2005). “Managerial Resourcefulness: Measuring a Critical Component of Leadership Effectiveness.” *The Journal of Entrepreneurship*, 14(1), 39-55.

Kates, R.W, Clark, W.C., Corell, R., Hall, J.M., Jaeger, C.C., Lowe, I., McCarthy,, J.J., Schellnhuber, H.J., Bolin, B., Dickson, N.M., Faucheux, S., Gallopin, C., Grübler, A., Huntley, B., Jäger, J., Jodha,N.S., Kasperson, R.E., Mabogunje, A., Matson, P., Mooney, H., Moore III, B., O'Riordan, T. and Svedlin, U. (2001). "Sustainability Science". *Science*, 5517(292), 641-642.

Keysar, E. and Pearce, A.R. (2007). “Decision Support Tools for Green Building: Facilitating Selection Among New Adopters on Public Sector Projects,” *Journal of Green Building*, 2(3), 153-171.

McCoy, A.P., Thabet, W., and Badinelli, R. (2007). *Towards Establishing a Domain Specific Commercialization Model for Innovation in Residential Construction.* Virginia Polytechnic Institute and State University*,* Blacksburg, VA.

Pacey, A. (1992). *The Culture of Technology*. MIT Press, Cambridge, MA.

Pearce, A.R., DuBose, J.R., and Bosch, S.J. (2007). “Green Building Policy Options in the Public Sector,” *Journal of Green Building,* 2(1), 156-174.

Pearce, A.R. and Fiori, C.M. (2009). "Synergistic Learning & Inquiry through Characterizing the Environment for Sustainability (SLICES): Improving Understanding of Real World Systems through Observation & Reflection". Proposal to the National Science Foundation Innovations in Engineering Education, Curriculum, and Infrastructure (IEECI) Program, Washington, DC, March.

Rogers, E.M. (2003). *Diffusion of Innovations.* Free Press, New York, NY.

Slater, S.F., and Mohr, J.J. (2006). Successful Development and Commercialization of Technological Innovation: Insight Based on Strategy Type. *The Journal of Product Innovation Management*, 1(23), 26-33.

Toole, T.M. (1998). “Uncertainty and Homebuilders’ Adoption of Technological Innovations”. *Journal of Construction Engineering and Management.* 124(4), 323-332.

Toole, T.M. (2001). “Technological Trajectories of Construction Innovation”. *Journal of Architectural Engineering*, 7(4), 107-114.