ACCEPTANCE OF WASTE-MINIMIZATION PRACTICES BY CONSTRUCTION MANAGEMENT STUDENTS

Mary Joan Williams B.S., C.M.,[1] MaryEllen C. Nobe, Ph. D.,[2]
Brian H. Dunbar, M. Arch.,[3] and Marvin E. Criswell, Ph. D., P. E.[4]

ABSTRACT

The purpose of this study was to assess the acceptance of a model of construction and demolition waste-minimization practices by construction management senior students. This approach assumed students can informally influence construction industry opinions, making their decisions vital to future construction-management education standards. The capstone class of the bachelor's degree program of one of the foremost construction management programs in the country was the sample chosen to study. It was found that a majority of the students were knowledgeable about all of the practices and had favorable opinions based on that knowledge. Most had tried more than half of the practices on a limited basis and decided they would use the practices based on these trials. The largest part of the students did not have experience applying a good number of the practices; however, almost all of those with this experience would continue to use all the practices. Identifying successful trial *and* application *experiences and asking students how they became involved in such experiences would be useful in the implementation of a school plan to increase acceptance.*

KEYWORDS

construction debris, materials efficiency, diffusion of innovations, opinion leadership

INTRODUCTION

Recovering Resources

Because of environmental regulations, the problem of debris is no longer one of preventing pollution, but one of recovering resources. Construction and demolition debris contributes significantly to landfill volumes, but the source materials comprising the waste stream present numerous waste minimization opportunities (U. S. Environmental Protection Agency [EPA], 2003). This research addresses the management question, *How can construction managers minimize the waste stream?* and answers the research questions, (1) *What is an appropriate model of construction-waste-minimization practices?* and (2) *Do current Construction Management senior students accept the construction-waste-minimization practices?* The study approach assumes construction management students can informally influence industry opinions through their role as opinion leaders. As such, they have the potential to cause an extremely rapid increase in innovation-acceptance rates (Rogers, 2003).

Regulation

On-site burning or burial of debris, open dumping, and incineration were common practices before landfilling, which was a result of the 1970s laws regulated by the U.S. Environmental Protection Agency (EPA) to protect surface and groundwater from serious contamination. The Resource Conservation Recovery Act (RCRA) of 1976 essentially changed waste management in the United States. The intent of the legislators was to bring state and federal governments

[1]Graduate Student; Department of Construction Management, Colorado State University; E-Mail: mary.williams@rams.colostate.edu.
[2]Assistant Professor; Department of Construction Management, Colorado State University; Phone: (970) 491-5215;
E-Mail: Mary.nobe@cahs.colostate.edu.
[3]Professor; Department of Construction Management, Colorado State University; Phone: (970) 491-5041;
E-Mail: dunbar@cahs.colostate.edu.
[4]Professor, Associate Dept. Head; Department of Civil and Environmental Engineering, Colorado State University;
Phone: (970) 491-6697; Email: mcriswel@engr.colostate.edu.

together to prevent—not to just cope—with pollution. The federal program sets minimum standards for programs that states regulate and tailor to their particular needs. RCRA encourages source reduction, recycling and safe disposal of hazardous and non-hazardous waste (EPA, 2003).

Construction Waste Minimization

Construction projects contributed an estimated 24% of the landfill volume on a national basis in 1996 (National Association of Home Builders, [n.d.]). Furthermore, the industry has a potential to produce debris from all materials manufactured for or related to construction. According to the United States Geological Survey (U.S. Geological Survey, 1998), in 1995 60% (more than 3,000 million short tons) of all non-food, non-fuel, raw materials consumed in the United States were for construction. Gershman, Brickner & Bratton (as cited in Franklin Associates, 1998) report the following sources of construction waste:

- Site clearance materials (brush, tree, and stumpage materials)
- Excavated materials (earth, fill, and other excavated rock and granular materials)
- Roadwork materials (concrete slabs and chunks from concrete road construction, asphalt chunks and millings from asphalt pavement, and bridge/overpass construction/renovation materials)
- New construction materials
- Renovation, remodeling or repair materials
- Demolition materials including wrecking, implosion, dismanteling, and deconstruction
- Disaster debris

Waste minimization, or procedures that reduce the amount of debris that enters the landfill waste stream from these sources, could produce numerous benefits. Environmental benefits include: reduced raw material production; less energy used to make products and reduced greenhouse gas emissions. In addition, less landfill space is required. Some of the economic paybacks are: decreased costs from regulating landfills and the related hauling expenses; enhanced public image; as well as lower prices for products as recycled materials replace virgin material sources and reused products replace newly manufactured products (EPA, 2000, 2002).

Consequently, the management question arises: *How can construction managers minimize the landfill waste stream?* Experience shows the answer is an emphasis on materials efficiency in every phase of a building's lifecycle (EPA, 2002). Some of the minimization practices employed by successful waste-reduction programs and documented by the EPA (2000) include:

- Building relocation
- Materials / structures reuse
- Recycled materials use
- Reduction goals included for award of the contract
- Contractor prequalification as deconstructor / recycler
- Contract requirements for materials processing
- Requirements included in the payment schedule
- Techniques and procedures education
- Employment of bonus / penalty incentives
- Documentation of efforts
- Communication channels for feedback.

Research Questions

The purpose of this study was to assess the acceptance of a model of construction and demolition waste-minimization practices by construction management (CM) senior students. The research questions for this purpose are (1) *What is an appropriate model of construction-waste-minimization practices?* and (2) *Do current Construction Management senior students accept the construction-waste-minimization practices?* This approach assumed CM students can informally influence construction industry opinions as opinion leaders. Opinion leaders have the potential to cause an extremely rapid increase in innovation-acceptance rates (Rogers, 2003), which makes their decisions vital to future construction-management education standards.

Definition of Terms

The following definitions are paraphrased from the EPA website and are provided to ensure understanding.

- *Debris* is manufactured and naturally occurring discards.
- *Greenhouse gas emissions* are discharges of gases such as methane and carbon dioxide that contribute to climate change.

- *Hazardous waste* is ignitable, corrosive, reactive, or toxic by-products of society that threaten human health or the environment.
- *Incineration* destroys waste by controlled burning at a high temperature.
- *Landfilled waste* is solid waste disposed at sites for non-hazardous solid wastes. Soil cover, compaction of layers, and liners prevent public health hazards and annoyances.
- *Materials efficiency* includes reduction, reuse, recycling, and the use of resource-efficient building products.
- *Open Dumping* of waste occurs at an uncovered site without environmental controls.
- *Reclamation* is restoration to a beneficial use, which may be different from the original.
- *Recycling* waste products involves processing for use as a raw material in manufacturing new products.
- *Reuse* is the use of a product more than once.
- *Source* reduction includes designing, manufacturing, purchasing, and/or using materials to reduce waste quantities.
- *Virgin material* is a raw natural resource.
- *Waste stream* is the flow of solid waste from all sources.

BACKGROUND

The construction process produces excessive amounts of construction waste, which often end up in landfills and is a major contributor to environmental pollution (EPA, June 2000). Construction managers, through their waste management plans and policies, have an opportunity to reduce this impact significantly (Glavinich, 2008). Reduced construction waste in landfills also has the potential to increase contractors' profits due to reduced landfill tipping fees (Laquatra and Pierce, 2002). Currently, ample *knowledge* about the importance and methods for implementing construction waste management plans exist, but industry opinion needs to shift as well if there is to be widespread implementation. Construction management students are in a position to influence industry opinions in their role as *opinion leaders* within the industry.

Evolution of the Model

The "model" aspect of the study evolved during a literature review organized to address the management-research question hierarchy (see Model Development in Research Methodology below). The choice of the Environmental Protection Agency (EPA) as a research source relied on the presumption of the agency's authority to regulate environmental issues, accessible and centralized information from a variety of sources and stability as a government entity verses a private enterprise. The exploration of the EPA website and resources introduced the topic of debris. The Municipal Solid Waste (MSW) report includes generation and management of solid waste, material composition of the solid-waste stream, and the products generated and recovered or discarded (EPA, October 2003a). The Franklin Associates (1998) report describes the composition of the Construction and Demolition (C&D) waste stream and the products generated and recovered or discarded. Both the MSW and C&D reports mention regulation of wastes in accordance with subtitle D of the Resource Conservation and Recovery Act (RCRA) (EPA, October 2003b). The RCRA Manual includes criteria addressing major aspects of MSW landfill regulation applicable to C&D landfills in many states. The MSW report is the only one to emphasize a "hierarchy" of management practices to address the increasing volumes of landfills. The other reports refer only to the practices themselves (i.e. recycling) in no order of preference. However, this precedence is important to a thorough understanding of materials efficiency.

The search for sources with detailed information, including the benefits of waste minimization, uncovered the *WasteWise* initiative. With this project, EPA draws information from various case studies addressing the construction-waste stream. Among the members of the initiative is the U.S. Green Building Council, developers of the Leadership in Energy and Environmental Design (LEED) Green Building Rating System™. LEED™ is widely accepted as a benchmark for sustainable design and construction. Waste minimization is related to the LEED™ rating system for "Materials and Resources". The February

2002 *WasteWise* newsletter, *Building for the Future*, gives a view of the quantity of C&D debris from the aspect of materials used for construction with the potential to become debris as opposed to those that have entered the waste stream. This concept emphasizes materials efficiency in every phase of a building's lifecycle, not solely disposal.

Through the *Waste Reduction Record-Setters Project*, EPA documents successful waste-reduction programs that can be used as models for other programs. One General Services Administration (GSA) model had potential waste-minimization practices for use in this study; however, GSA removed the webpage. Consequently, it was necessary to search to find the EPA project's fact sheet set, *Building Savings: Strategies for Waste Reduction of Construction and Demolition Debris from Buildings* for the construction-waste-minimization practices (EPA, June 2000). The *WasteWise* newsletter, *Building for the Future,* organizes strategies into project phases similar to the GSA model (EPA, February 2002). As a result, it was possible to reconstruct (with the exception of the "biodegradable landfill" strategy) the GSA model as follows:

- Project Design. *Building relocation, materials / structures reuse, recycled materials use*
- Specifications and Contract. *Reduction goals included for award of the contract, contractor prequalification as deconstructor / recycler, contract requirements for materials processing, requirements included in the payment schedule*
- Project Construction. *Techniques and procedures education, employment of bonus / penalty incentives, documentation of efforts, communication channels for feedback.*

This listing of key points/concepts was envisioned as the model of waste-minimization practices for construction managers for this study.

Diffusion of the Innovation

The model was then considered as an "innovation"—defined as an idea, practice or object by Rogers in his book, "Diffusion of Innovations" (2003, p. 169). He asserts that the adoption of an innovation is a process with five stages:

1. *Knowledge*, awareness of the existence and some understanding of the function of an innovation.
2. *Persuasion*, formation of a favorable or unfavorable attitude towards the innovation.
3. *Decision*, engagement in activities leading to a choice to adopt or reject the innovation.
4. *Implementation*, to put into use.
5. *Confirmation*, reinforcement of the decision.

Additionally, Rogers (2003, p. 27) writes that *opinion leaders* are individuals who can informally influence the opinions of others. In fact, they have the potential to affect innovation-adoption-rate curves exponentially. The assumption "opinion leadership" was applicable to college graduates was based on Rogers' (2003, pp. 308–312) concept of *informant's ratings* or identification by knowledgeable people. According to him, it is one of the main methods used in the past of measuring opinion leadership and is as valid as any of the other three methods he mentions: (1) *sociometric techniques,* (2) *self-designating techniques* and (3) *observation*. In the case of college students, educators and employers were people who knew about the ability of college students to influence the opinions of others.

Rogers (2003, pp. 402–403) further states there is more than one type of innovation-decision. Independent decisions by an individual (*optional*) often must follow prior decisions by a *collective* or *authority*. This concept can be applied to a student at a college as well, because of elective educational offerings and mandatory courses made available through the school. Therefore, the decisions of college students are made vital to construction-management education standards.

RESEARCH METHODOLOGY

Overview

The Rogers' (2003) diffusion model was applied in this study of the acceptance by Construction Management senior students of selected construction-waste-minimization practices.

Model Development

The model of construction-waste-minimization practices used in this research was based on a General Services Administration (GSA) model that answered the investigative questions of the research hierarchy:

What are CM responsibilities relative to waste reduction?

What are the responsibilities assigned to the basic aspects of construction: project design, specifications and contract, project construction?

What are the reduction principles that apply?

What practices augment the reduction principles? (see Appendix A for complete research hierarchy).

The model was intended to be a general listing of key points and concepts related to materials efficiency and construction management. Since the strategies were drawn from case studies recognized as "successful" by authorities such as the GSA and the Environmental Protection Agency, review and critique were not considered. The survey results were not input to revise the model because participant decisions about the practices involved could change in future research.

Participants

A *judgment sample* from the population of Colorado State University Construction Management (CM) undergraduates was chosen as the most practical sample for this study. This type of sample is a nonprobability sample, one that conforms to certain criteria. The selection criteria were based on the assumption that CM students are potential opinion leaders in the construction industry. Opinion leaders are individuals with the ability to informally influence the opinions of others (Rogers, 2003). Colorado State University's CM program is regarded as one of the foremost in the country. The structure of the Construction Management program can support the experiences necessary to promote acceptance by the students such as course offerings in sustainability, which should include waste minimization because it is an important environmental consideration. Study participants came from CON 465: CM Professional Practice. This course, considered the capstone class of the bachelor's degree program, provides a cross section of students at a point where they have the full benefit of any opportunities including internship. There were two lecture sections of the class for the Spring 2009 semester totaling approximately 104 students to participate in the study.

Instrumentation

Measurement questions for the preliminary questionnaire targeted the construction-waste-minimization practices suggested by the General Services Administration (GSA) model. The practices were arranged according to the project phases used in the original model (*design*, *specifications* and *contract*, then project construction). Practices were defined by examples of projects from the EPA website. Each of the stages of Roger's (2003) diffusion model for all of the minimization practices were addressed with two-way or multiple choice response nominal scale questions. Ordinal scale questions were avoided because they would provide extraneous data, as Roger's asserts that uncertainty hinders acceptance. The one exception is Question 11 that allows "Modify" as a choice indicating acceptance. Rogers generalizes that modifications to innovations lead to faster acceptance and longer use. Classification questions concerned the three important characteristics for participants: (1) CM undergraduate student at CSU (2) CM Professional Practice class member (3) Tentative Spring 2009 graduate (see *Participants* section). Since a requirement to retake a course after completion of Professional Practice is possible, a question about the tentative graduation term was included to ensure completion of program requirements (see Appendix C for complete questionnaire).

Data Collection Method

The survey approach to the collection of data for the final study was a *mixed method* that combined a self-administered questionnaire with interviewer assistance. Letter-sized copies of the questionnaire and cover letter were printed, then distributed and collected during prearranged class time. The cover letter described the research, benefits and risks, and efforts to protect participants' right. Each student received a copy when entering the classroom and returned it when completed. During this time, participants were allowed to ask questions about the instructions.

Procedures

The instrument was refined by *non-collaborative* field-testing of *participant surrogates* drawn from one recitation section of the Fall 2008 CM Professional Practice class members. These individuals had characteristics and backgrounds similar to the sample participants. Each received a copy of the questionnaire using the same data collection method as the sample participants. The results were used to revise the instrument and method. No instrument corrections were necessary and the data collection method was simplified. The revised questionnaire is provided in Appendix C.

Data Preparation and Summary

Data preparation consisted of precoding, central editing, and keyboard entry using a spreadsheet for the data file. Each *characteristic*, *practice* and *underlying principle* on the questionnaire was assigned labels for use in the spreadsheet and graphs. The data were checked for accuracy, consistency, uniformity, completeness, and arrangement of the responses. Editing notes referenced answers changed or supplied by the editor for inconsistent responses. The spreadsheet developed for entering and viewing the data tallied the responses to each question from respondents with the desired characteristics. The number of positive responses, or those indicating acceptance, was compared to the total of positive and negative responses to the question. The results were expressed as percents and displayed in the *Findings* graphs (see Appendix B for an explanation of graph labels). Responses in survey format are provided in Appendix C.

Nature and Form of Results

The report describes the acceptance of each of the waste-minimization practices by the Professional Practice class participants or a plan to further acceptance, when necessary. With this approach, there is also a potential for progress assessments of the selected practices, assessments of different practices or detailed assessments of a selected practice.

FINDINGS

A total of 51 students, 49% of the total students taking the class, attended and received questionnaires. Two questionnaires were not returned, and four were invalidated because recipients were not Construction Management Professional Practice class members or graduation candidates. While a 49% return rate is decent, a higher rate may have allowed for more significant feedback and results.

Participants were first asked if they were aware of the existence of each of the construction-waste-minimization practices. Almost all knew of *Use of recycled materials*, followed by *Materials / structures reuse*. A majority had knowledge of the remaining practices, except *Building relocation* with 50% (see Figure 1). More than half of the respondents felt they had the information necessary to apply the practices to a construction project, especially *Recycled materials use* and *Reuse of materials and structures* (see Figure 2) A considerable portion of the students (75% to 96%) indicated they understood the underlying principles of the construction-waste-minimization practices. *Structure relocation* was the exception with only 54% (see Figure 3).

Most (more than 80%) of the attitudes towards any practice were positive if the respondents had any type knowledge of the practice (see Figure 4). When asked whether they or someone they considered their peer had tried a practice on a limited basis such as a lab, demonstration, site visit, or workshop, the responses varied considerably. A majority (52–63%) indicated trying *Requirements included in the payment schedule*, *Techniques and procedures education*, *Communication channels for feedback*, and *Documentation of efforts*. *Recycled materials use* (77%) and *Materials / structures reuse* (79%) where tried most frequently. Less than half of the respondents indicated trials of the remaining practices (see Figure 5). As a result of such trials by the respondent or peer, 71–97% decided they would use the all the practices (see Figure 6). Less than 40% of the students indicated internship, work-study or similar experience applying most of the practices.

The exceptions were *Documentation of efforts* (52%), *Communication channels for feedback* (53%), *Materials / structures reuse* (64%) and *Recycled materials use* (68%) (see Figure 7). Almost all (91–100%) of the students decided they would continue the practices based on their experience applying it (see Figure 8).

FIGURE 1. Positive responses to the survey question, *Were you aware of the existence of the following construction-waste-minimization practices?*

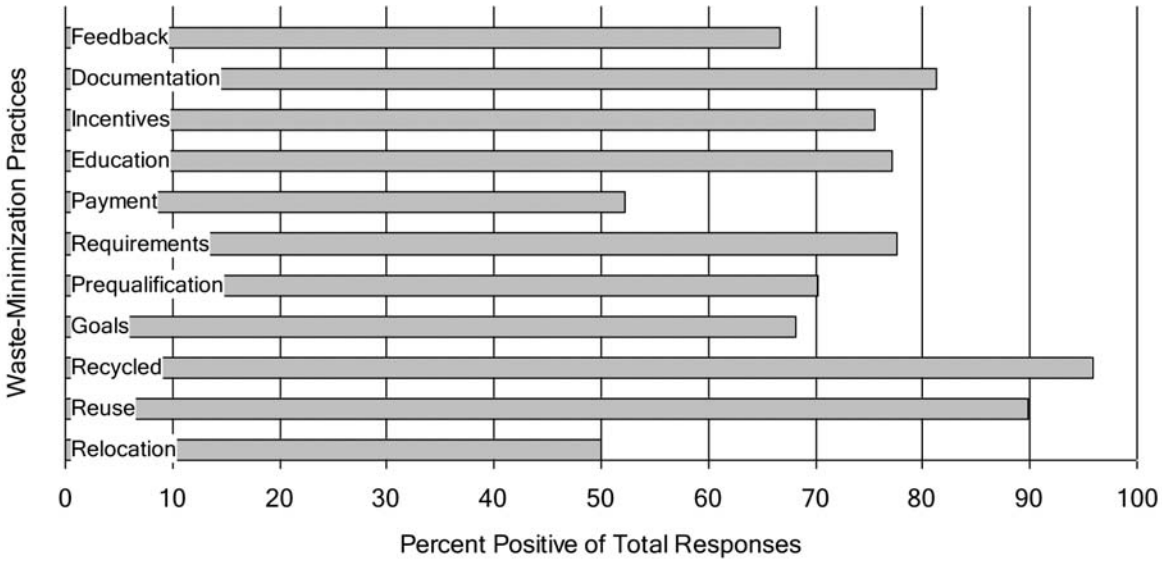


FIGURE 2. Positive responses to the survey question, *Do you feel you have the information necessary to apply the practice to a construction project?*

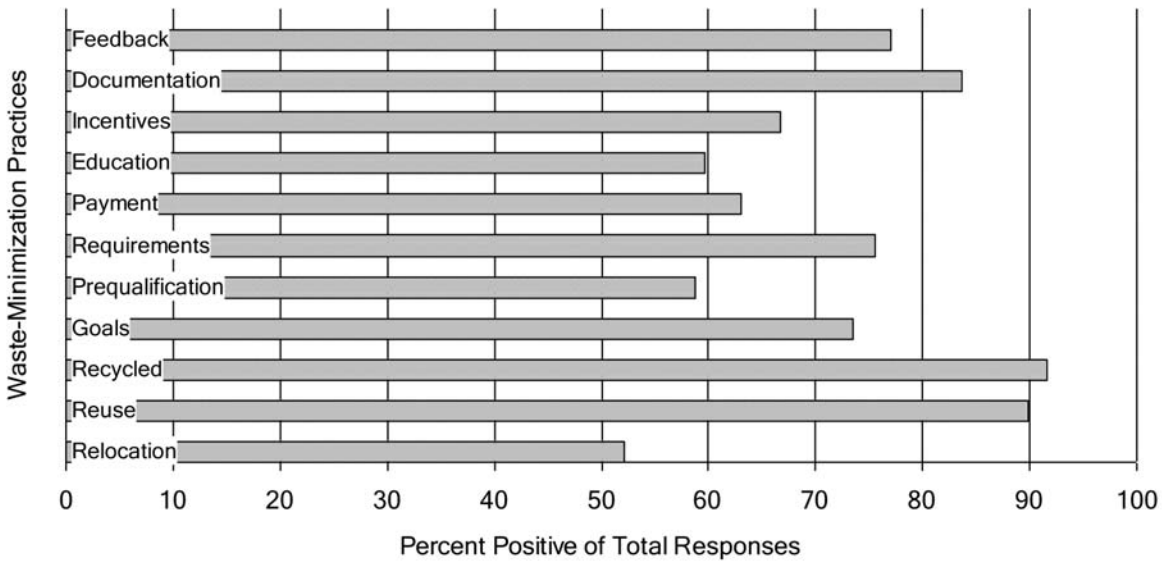


FIGURE 3. Positive responses to the survey question, *Please indicate whether you understand the following underlying principles of the construction- waste-minimization practices.*

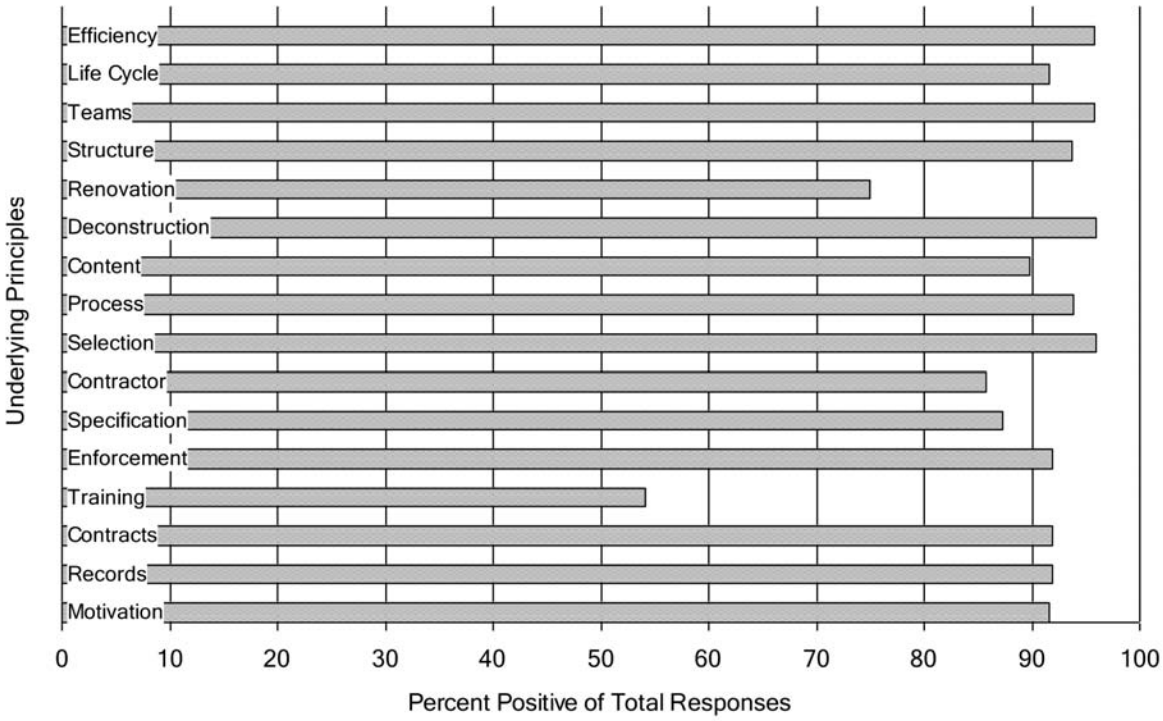


FIGURE 4. Positive responses to the survey question, *If you had any knowledge of the practice, please indicate whether your attitude towards it is positive or negative.*

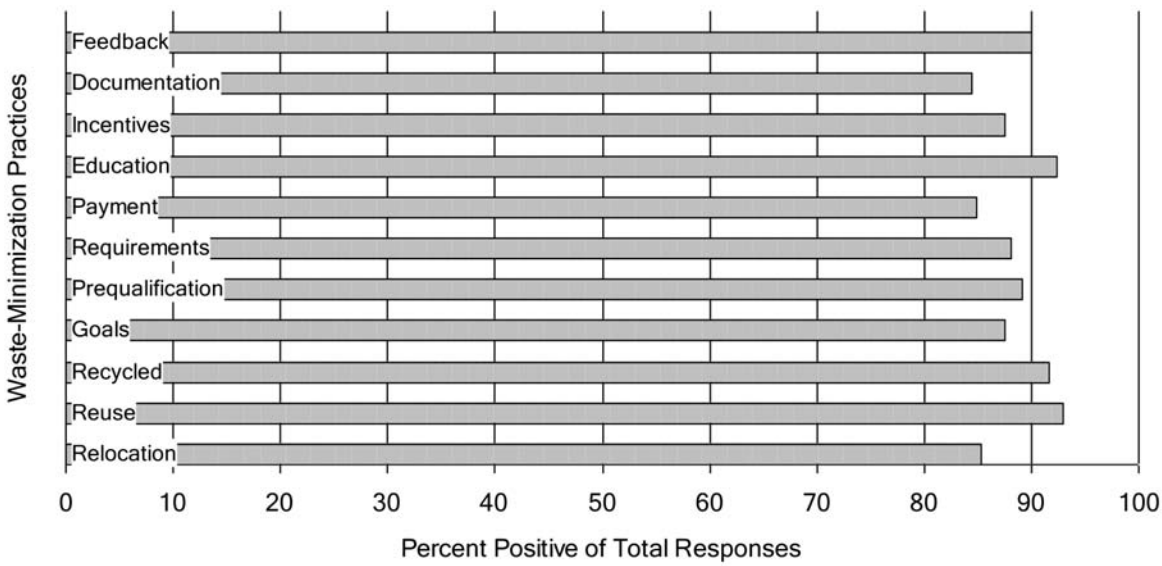


FIGURE 5. Positive responses to the survey question, *Please indicate whether you or someone you consider your peer, has tried the practice on a limited basis such as a lab, demonstration, site visit, or workshop.*

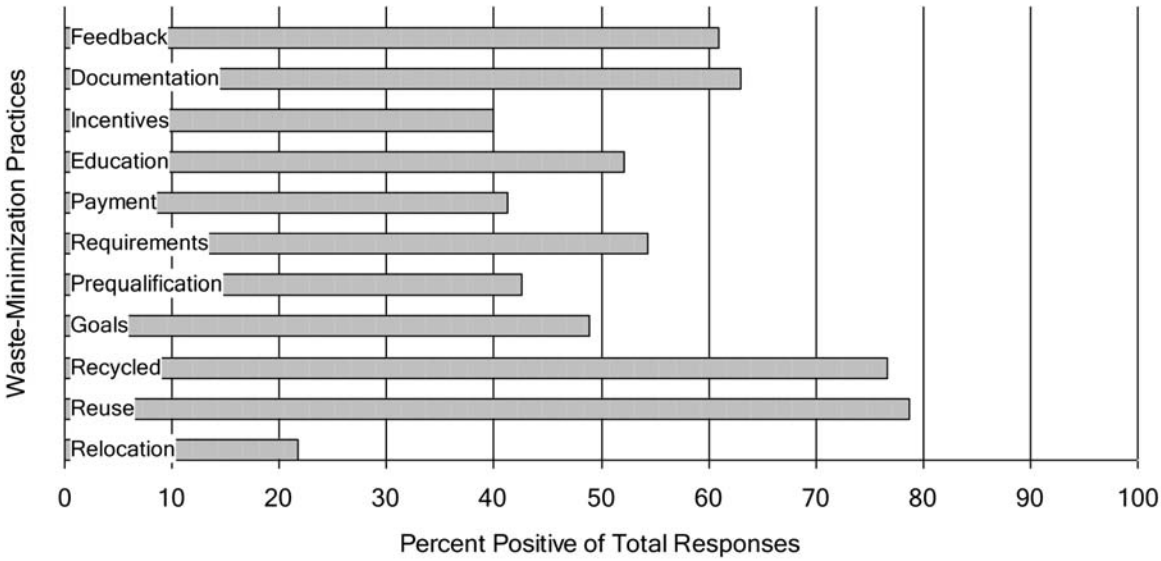


FIGURE 6. Positive responses to the survey question, *As a result of such trials by you or your peer, did you decide you would use or reject the practice?*

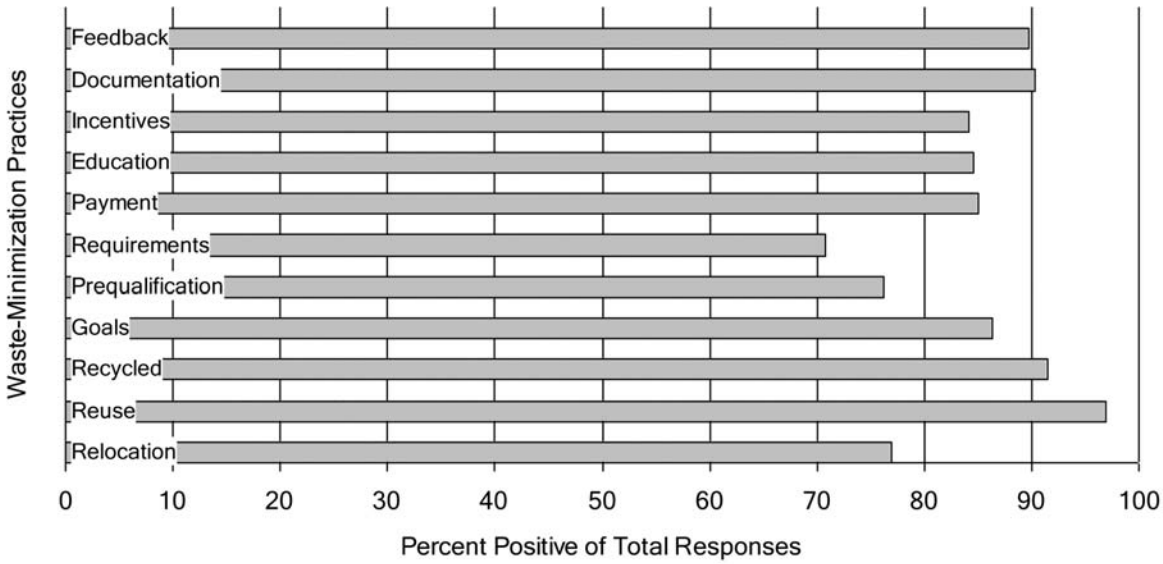


FIGURE 7. Positive responses to the survey question, *Please indicate whether you have internship, work-study or similar experience applying the practice.*

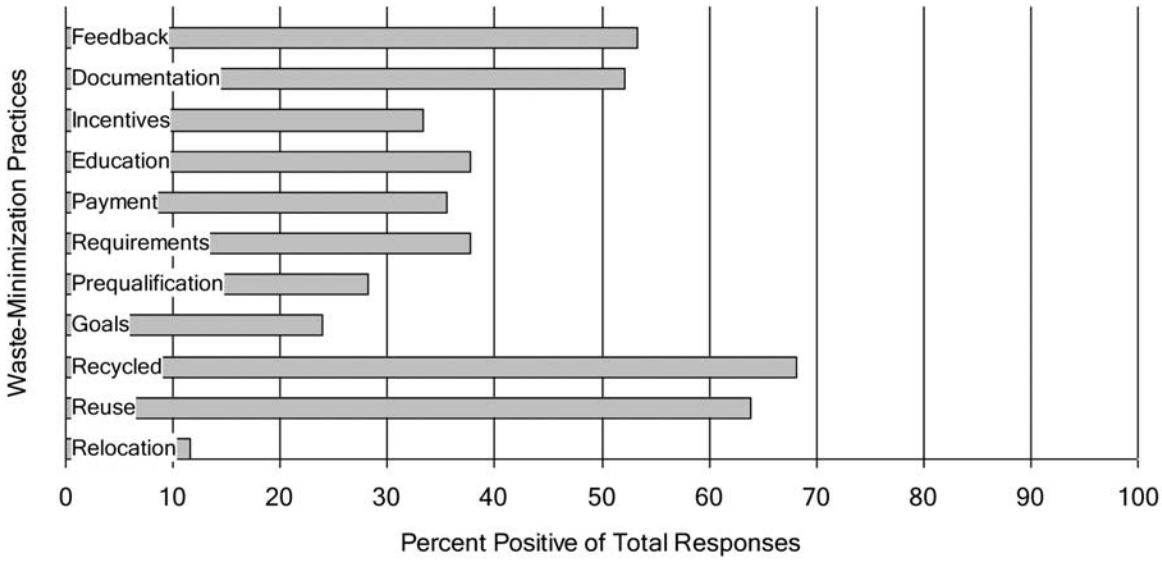
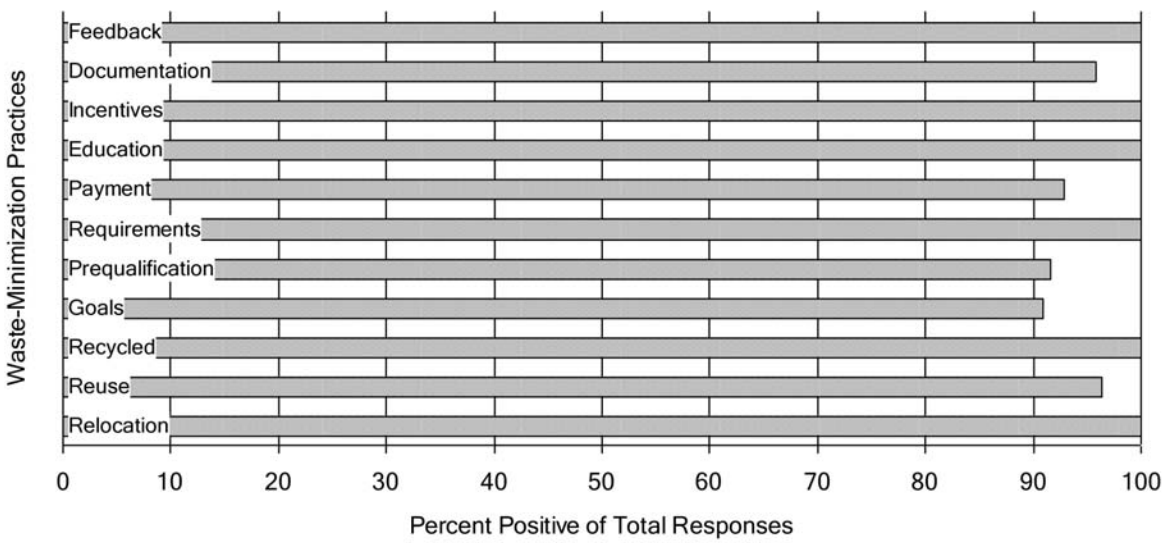


FIGURE 8. Positive responses to the survey question, *Did you decide you would continue to use, modify, or discontinue the practice based on your experience applying it?*



CONCLUSIONS

Discussion

In asking whether current Construction Management senior students accept the construction-waste-minimization practices comprising the research model, several conclusions were reached based on the simple majority of answers.

Building Relocation, Reduction Goals for Award of the Contract, Contractor Prequalification as Deconstructor / Recycler, Requirements Included in the Payment Schedule, Employment of Bonus / Penalty Incentives

The students knew these practices and that was enough to give most of them a favorable opinion. Nearly all of those who had tried the practices on a limited basis such as a lab, demonstration, site visit, or workshop decided they would use them; however, a large number had not tried the practices. An even larger number had no internship, work-study or similar experience applying the practices; all who had applied the practices would continue their use. These decisions to continue probably result from successful trials and applications.

Materials / Structures Reuse, Recycled Materials Use, Documentation of Efforts, Communication Channels for Feedback

A majority of the students accepted the four practices. Little uncertainty should exist when students are knowledgeable and have had success trying and applying the practices.

Requirements Included in the Payment Schedule, Techniques and Procedures Education

Students had favorable opinions towards these practices based on their knowledge; they decided to use or continue to use these practices after trying or applying them. However, many had tried these practices but did not have experience applying them. This may be due to unavailability of appropriate experiences.

Lab, demonstration, site visit, workshop or similar opportunities for trial of the practices should be readily available. In addition, it would be advantageous for construction management students to experience best practices of construction-waste management in their internships and work-studies. Ideally, such an array of educational experiences would be required for graduation from construction courses and programs.

This would require coordination between students, educators and construction professionals. For example, instructors can search for opportunities to *try* the practices and include these in their lesson plans. Students can request experience *applying* the practices in their work applications. Construction professionals can ensure opportunities to *try* or *apply* the practices are posted appropriately. Advisors can make job postings available to students.

Areas for Further Research

Subsequent to data collection, editing notes revealed the necessity to revise the questionnaire prior to future use to allow respondents to indicate when response choices are not applicable to their situation. Additionally, numbering questions to show dependence on preceding questions and some wording changes for clarity seemed indicated in some cases, as well.

Attempting to identify successful *trial* and *application* experiences and asking students how they became involved in such experiences would be useful in the implementation of a school plan to increase acceptance. Once program changes to further acceptance of the practices are made, the Construction-Waste-Minimization Study survey can be administered again to document success or to adjust the school plan.

These recommendations will improve the quality of a Construction Management program, positively affecting students and influencing the industry. Progress in the industry will, in turn, result in better *trial* and *application* opportunities that will expand the Construction Management program in the area of materials efficiency.

ACKNOWLEDGMENTS

Thanks to the Colorado State University Construction Management Department for their co-operation in the conduct of the survey.

REFERENCES

Franklin Associates. (1998). Characterization of Building-related Construction and Demolition Debris in the United States (Report EPA530-R-98-010). Retrieved October 31, 2003, from U.S. Environmental Protection Agency Web site: http://www.epa.gov/epaoswer/hazwaste/sqg/c&drpt.pdf .

Glavinich, T. E. (2008). Contractor's Guide to Green Building Construction. John Wiley and Sons, Inc.: Hoboken, New Jersey.

Laquatra J. and Pierce, M. R. (2003). Waste Management at the Construction Site. Ithaca, NY: Cornell University. Retrieved July 18, 2010 from http://www.human.cornell.edu/che/DEA/outreach/upload/Waste_Management-booklet.pdf .

National Association of Homebuilders and Home Builders Institute. (n.d.) Building a Balance: Housing Affordability and Environmental Protection. (Fact sheet).

Rogers, E.M. (2003). Diffusion of Innovations (5th ed.). New York: Simon & Schuster, Inc.

U.S. Environmental Protection Agency. (1997, July). Landfill Reclamation (Fact sheet EPA530-F-97-001). Retrieved October 31, 2003 from U.S. Environmental Protection Agency Web site: http://www.epa.gov/wastes/nonhaz/municipal/landfill/land-rcl.pdf .

U.S. Environmental Protection Agency. (2000, June). Building Savings: Strategies for Waste Re-duction of Construction and Demolition Debris from Buildings (Fact sheet EPA-530-F-00-001g). Retrieved October 31, 2003 from U.S. Environmental Protection Agency Web site: http://www.epa.gov/garage/pubs/combined.pdf .

U.S. Environmental Protection Agency. (2002, February). Building for the Future. WasteWise Update (Newsletter EPA530-N-02-003). Retrieved October 31, 2003 from U.S. Environmental Protection Agency Web site: http://www.epa.gov/wastewise/pubs/wwupda16.pdf .

U.S. Environmental Protection Agency. (2003a, October). Municipal Solid Waste in the United States: 2001 Facts and Figures (Report EPA530-R-03-011). Retrieved October 31, 2003 from .http://www.epa.gov/epaoswer/non-hw/muncpl/pubs/msw2001.pdf

U.S. Environmental Protection Agency. (2003b, October). RCRA Orientation Manual (Report EPA-530-R-06-003). Retrieved October 31, 2003 from http://www.epa.gov/epaoswer/ general/orientat/rom2.pdf .

U.S. General Services Administration Homepage. (n.d.). Retrieved September 18, 2003, from http://www.gsa.gov/Portal/content/offerings_content.jsp?contentOID=116951&contentType=1004.

U.S. Geological Survey. (1998, June). Materials Flow and Sustainability (Fact sheet FS-068-98). Retrieved March 6, 2008 from http://greenwood.cr.usgs.gov/pub/fact-sheets/fs-0068-98/fs-0068-98.pdf.

APPENDIX A

Research Hierarchy

Management Dilemma

The increasing landfill volumes

Management Question

How can construction managers minimize the waste stream?

Research Question	**Research Question**
What is an appropriate model of construction-waste-minimization practices?	Do current Construction Management senior students accept the construction-waste-minimization practices?
Investigative Questions	**Investigative Questions**
What are CM responsibilities relative to waste reduction?	What are the typical college learning experiences of CM students?
What are the responsibilities assigned to the basic aspects of construction: project design, specifications and contract, project construction?	How do college learning experiences relate to the acceptance of technology?
What are the reduction principles that apply?	What are the decisions CM students make based on their experiences?
What practices augment the reduction principles?	

Measurement Questions

Were you aware of the existence of the following construction-waste-minimization practices?

Yes No

- Building relocation.
- Materials / structures reuse.
- Recycled materials use.
- Reduction goals for award of the contract.
- Contractor prequalification as deconstructor / recycler.
- Contract requirements for material processing.
- Requirements included in the payment schedule.
- Techniques and procedures education.
- Employment of bonus / penalty incentives.
- Documentation of efforts.
- Communication channels for feedback.

Do you feel you have the information necessary to apply the practice to a construction project?

Yes No

- Relocate a building
- Reuse materials / structures
- Use recycled materials
- Set reduction goals for award of the contract
- Prequalify contractor as deconstructor / recycler
- Include material processing requirements in the contract
- Include requirements in the payment schedule
- Techniques and procedures education
- Employ bonus / penalty incentives
- Document efforts
- Provide communication channels for feedback

Please indicate whether or not you understand the following underlying principles of the construction-waste minimization practices.

Yes	No	
		Materials efficiency
		Life cycle assessment
		Planning and design teams
		Structure relocation
		Renovation
		Deconstruction
		Recycled-content products
		Recycling process
		Contractor selection
		Contractor prequalification
		Plans and specifications
		Enforcement mechanisms
		Employee training programs
		Incentive contracts
		Job records
		Employee motivation

If you had any knowledge of the practice, please indicate whether your attitude towards it is positive or negative.

Positive Negative

Please indicate whether you or someone you consider your peer, has tried the practice on a limited basis such as a lab, demonstration, site visit, or workshop.

Yes No

As a result of such trials by you or your peer, did you decide you would use or reject the practice?

Use Reject

Please indicate whether you have internship, work study or similar experience applying the practice.

Yes No

Did you decide you would continue to use, modify, or discontinue the practice based on your experience applying it?

Continue Modify Discontinue N / A

Management Decision

Note. Listing of the construction-waste-minimization practices is omitted after the initial listing.

APPENDIX B

Characteristics, Practices and Underlying Principles Labels

Characteristic, Practice or Underlying Principle	Graph Label	Data File Label
Characteristics		
Construction Management major	Major	MJR
Professional Practice class member	Class	CM
Spring 2009 graduation	Graduation	SPR
Practices		
Building relocation	Relocation	BR
Materials / structures reuse	Reuse	MSR
Recycled materials use	Recycled	RMU
Reduction goals for award of the contract	Goals	RG
Contractor prequalification as deconstructor / recycler	Prequalification	CP
Contract requirements for material processing	Requirements	CR
Requirements included in the payment schedule	Payment	RPS
Techniques and procedures education	Education	TPE
Employment of bonus / penalty incentives	Incentives	BPI
Documentation of efforts	Documentation	DE
Communication channels for feedback	Feedback	CCF
Principles		
Materials efficiency	Efficiency	ME
Life cycle assessment	Life cycle	LCA
Planning and design teams	Teams	PDT
Structure relocation	Structure	SR
Renovation	Renovation	R
Deconstruction	Deconstruction	D
Recycled-content products	Content	RCP
Recycling process	Process	RP
Contractor selection	Selection	CS
Contractor prequalification	Contractor	CQ
Plans and specifications	Specifications	PS
Enforcement mechanisms	Enforcement	ENM
Employee training programs	Training	ETP
Incentive contracts	Contracts	IC
Job records	Records	JR
Employee motivation	Motivation	EM

APPENDIX C

Questionnaire and Summary of Responses

Construction- Waste Minimization Study

1. Are you majoring in Construction Management at CSU?

Yes	No	If no, do not complete the survey.
50	0	

2. Are you a CM Professional Practice class member?

Yes	No	If no, do not complete the survey.
50	0	

3. Do you plan to graduate Spring Semester 2009?

Yes	No	If no, do not complete the survey.
50	0	

4. Were you aware of the existence of the following construction-waste-minimization practices? (See definitions at end of survey)

Yes	No	
24	24	Building relocation.
44	5	Materials / structures reuse.
47	2	Recycled materials use.
32	15	Reduction goals for award of the contract.
33	14	Contractor prequalification as deconstructor / recycler.
38	11	Contract requirements for material processing.
24	22	Requirements included in the payment schedule.
37	11	Techniques and procedures education.
37	12	Employment of bonus / penalty incentives.
39	9	Documentation of efforts.
32	16	Communication channels for feedback.

5. Do you feel you have the information necessary to apply the practice to a construction project?

Yes	No	
24	22	Relocate a building
44	5	Reuse materials / structures
44	4	Use recycled materials
36	13	Set reduction goals for award of the contract
27	19	Prequalify contractor as deconstructor / recycler
37	12	Include material processing requirements in the contract
29	17	Include requirements in the payment schedule
28	19	Techniques and procedures education.
32	16	Employ bonus / penalty incentives
41	8	Document efforts
37	11	Provide communication channels for feedback

6. Please indicate whether or not you understand the following underlying principles of the construction-waste-minimization practices.

Yes	No	
44	4	Materials efficiency
45	4	Life cycle assessment
45	4	Planning and design teams
26	22	Structure relocation
45	4	Renovation
41	6	Deconstruction
42	7	Recycled-content products
47	2	Recycling process
46	3	Contractor selection
44	5	Contractor prequalification
47	2	Plans and specifications
36	12	Enforcement mechanisms
45	3	Employee training programs
46	2	Incentive contracts
44	4	Job records
46	2	Employee motivation

7. If you had any knowledge of the practice, please indicate whether your attitude towards it is positive or negative.

Positive	Negative	
29	5	Building relocation
40	3	Materials / structures reuse
44	4	Recycled materials use
35	5	Reduction goals for award of the contract
33	4	Contractor prequalification as deconstructor / recycler
37	5	Contract requirements for material processing
28	5	Requirements included in the payment schedule
36	3	Techniques and procedures education
35	5	Employment of bonus / penalty incentives
38	7	Documentation of efforts
36	4	Communication channels for feedback

8. Please indicate whether you or someone you consider your peer, has tried the practice on a limited basis such as a lab, demonstration, site visit, or workshop.

Yes	No	
10	36	Building relocation
37	10	Materials / structures reuse
36	11	Recycled materials use
23	24	Reduction goals for award of the contract
20	27	Contractor prequalification as deconstructor / recycler
25	21	Contract requirements for material processing
19	27	Requirements included in the payment schedule
24	22	Techniques and procedures education
18	27	Employment of bonus / penalty incentives
29	17	Documentation of efforts
28	18	Communication channels for feedback

9. As a result of such trials by you or your peer, did you decide you would use or reject the practice?

Use	Reject	
10	3	Building relocation
32	1	Materials / structures reuse
32	3	Recycled materials use
19	3	Reduction goals for award of the contract
16	5	Contractor prequalification as deconstructor / recycler
17	7	Contract requirements for material processing
17	3	Requirements included in the payment schedule
22	4	Techniques and procedures education
16	3	Employment of bonus / penalty incentives
28	3	Documentation of efforts
26	3	Communication channels for feedback

10. Please indicate whether you have internship, work study or similar experience applying the practice.

Yes	No	
5	38	Building relocation
30	17	Materials / structures reuse
32	15	Recycled materials use
11	35	Reduction goals for award of the contract
13	33	Contractor prequalification as deconstructor / recycler
17	28	Contract requirements for material processing
16	29	Requirements included in the payment schedule
17	28	Techniques and procedures education
15	30	Employment of bonus / penalty incentives
25	23	Documentation of efforts
24	21	Communication channels for feedback

11. Did you decide you would continue to use, modify, or discontinue the practice based on your experience applying it?

Continue	Modify	Discontinue	No experience	
4	1	0	41	Building relocation
23	3	1	18	Materials / structures reuse
26	3	0	16	Recycled materials use
8	2	1	35	Reduction goals for award of the contract
9	2	1	35	Contractor prequalification as deconstructor / recycler
14	2	0	29	Contract requirements for material processing
11	2	1	30	Requirements included in the payment schedule
14	2	0	29	Techniques and procedures education
11	4	0	31	Employment of bonus / penalty incentives
18	5	1	23	Documentation of efforts
18	5	0	20	Communication channels for feedback