AC 2010-636: THE EMERGENT NECESSITY FOR DEMOLITION AND RECONSTRUCTION CONTENT IN THE CONSTRUCTION TECHNOLOGY CURRICULUM

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Mark's 30+ years of construction industry experience includes owning and operating a custom homebuilding company in addition to senior management positions with one of the largest homebuilders in the nation as well as a regional commercial/residential development company in Florida. He has also worked as a research engineer for the National Association of Home Builders Research Foundation where he was a project manager for the EER energy efficiency research and demonstration residence. He recently completed his Ph.D. concentrating on reconstruction and demolition with a cognate specialty in education. He currently teaches in and administers the Purdue Department of Building Construction Management's Demolition and Reconstruction concentration, the first college level program in the nation with an emphasis on the management of demolition projects.

The Emergent Necessity for Demolition and Reconstruction Content in the Construction Technology Curriculum

Abstract

The construction industry has begun to encounter with increasing frequency projects that involve existing built environments. These activities require sensitivity to existing conditions and entail a greater probability of unforeseen project characteristics than might be encountered in new construction on vacant land. Many of these projects receive limited guidance from design professionals. Consequently, when executing demolition and reconstruction projects, the construction practitioner is required to have a greater understanding of the regulatory environment of codes and standards. In addition, they must become a more creative participant in the project as they respond to existing conditions as opposed to following the detail provided by plan and specification documents. To help prepare construction technology students for the management of projects that do not begin with a blank sheet of paper, construction education programs have an increasing need to include demolition and reconstruction content in their curriculum.

Creating undergraduate course content that presents knowledge not previously provided at the university level has many challenges, not the least of which are anticipation of the career aspirations of the students enrolled and the expected educational outcomes required by the industry. This paper examines the basis for advancement of demolition and reconstruction in construction education, the development and administration of course content in the construction curriculum to support this growing need, and available resources to support future course evolution.

Introduction

Post-secondary construction education in the United States during the twentieth century was fundamentally concerned with new construction work. As the built environment within the United States ages, it is anticipated that opportunities in demolition and reconstruction will continue to expand. In a recent survey of owners responsible for facility construction and maintenance, FMI, a management consulting and investment banking firm to the building and construction industry, and the Construction Management Association of America (CMAA) outlined a set of seven challenges they believe will cause construction markets to change direction in the near future. The first challenge outlined indicated that "Aging infrastructure in nearly every market segment is at or beyond its current useful life…represent(ing) trillions of dollars in necessary spending over the next 10 to 20 years to upgrade and replace these assets"[1].

The demolition industry through the National Demolition Association (NDA) has also expressed a desire to attract a college educated workforce and to advance professionalism within the demolition industry. It is believed that many misconceptions about the activities of demolition contractors are held by the general public, general contractors, and young construction professionals. The most frequently cited misconceptions include the belief that demolition contractors primarily "blow-up" buildings, recycle very little, operate unsophisticated businesses,

and can successfully complete demolition activities with little knowledge or experience[2]. As a result, the National Demolition Association perceived a need for university construction management programs that include demolition in the undergraduate curriculum. The board of directors of the NDA has expressed a need for courses that will help the general contractors and construction managers of the future better manage the demolition process in addition to providing students with a background appropriate for employment in the demolition industry.

Identification of the need for college level education in demolition is not unique to the United States. In the spring 2008 issue of *Demolition Engineer*, a publication of the British Institute of Demolition Engineers, it was noted that demolition industry changes in the last 20 years have introduced stringent legislation, greater levels of administration, and increases in the complexity of demolition[3]. These changes have moved the industry toward a greater level of professionalism with a need for demolition specific college courses. Construction education was suggested as a possible entry to demolition, yet specific challenges encountered in demolition, most notably the complexity of waste management, are not a topic of study in construction programs in the United Kingdom.

The academic community must decide if the management of demolition and reconstruction is an area of competency appropriate for construction education programs. If so, what is an appropriate level of content to include in the curriculum? Industry practitioners are a possible source of guidance in this process. Cooperation with industry practitioners can lead to many forms of collaboration with faculty such as curriculum enhancements, identification of potential research direction, and joint educational or research opportunities[4]. Tener suggests that design and continuous updating of the construction engineering curriculum is a fundamental function that requires the university to collaborate with industry practitioners[5].

Some take a more negative view of industry's influence on education. In her book *University, Inc.* Jennifer Washburn describes repeated instances where influence from industry (and corporate contributions) is suspected as the cause of questionable decisions by universities or even manipulated research results[6]. Although many of her allegations are circumstantial, she does make a substantial case that money influences what is taught in many situations. In a recent example, IBM helped to develop curriculum and awarded grants to North Carolina State University with the goal of providing students a better background for employment with IBM[7]. Is this a breach of academic integrity and independence, or merely an instance that requires faculty to realign their teaching activities to suit the emerging job market?

In the experience of the author, it is necessary to take into account the potential for conflicts of interest when engaging practitioners in the educational process. Those involved in curriculum development must be cognizant of the need for curriculum that is broad enough to suit a sufficiently wide range of potential employers that will allow their students career flexibility. In addition to possible disagreement about expected educational outcomes, there may also be misunderstandings about content and potential for bias. It is the author's suggestion that while collaborating on the educational process these potential issues should be explored in an open dialogue between faculty and practitioners. Those involved in the educational collaboration should also keep in mind that a faculty member is as likely as an industry practitioner to harbor bias that can influence the process.

Accreditation Considerations

Accreditation guides the minimum standards for educational objectives in post-secondary construction education programs. Educational outcomes from construction programs that influence career and professional accomplishments, as well as specific skills, knowledge, and behaviors, are described in accreditation criteria. Because of the importance of accreditation, curriculum decisions are frequently influenced by the core competencies specifically referenced by accreditation bodies.

The two primary accreditation bodies for post-secondary construction education programs are the Accreditation Board for Engineering and Technology (ABET) and the American Council for Construction Education (ACCE). The most recently issued criteria for ABET accreditation of construction technology or construction engineering programs do not specifically mention demolition activities[8, 9]. Nevertheless, demolition and reconstruction activity, when part of an overall project, is implicit in the ABET required proficiencies encompassing construction processes, communications, methods, materials, systems, equipment, planning, scheduling, safety, cost control, and management. ACCE makes a more definitive statement in favor of integrating demolition and reconstruction requirements into the curriculum. In the general requirements of the accreditation criteria for construction education programs, the ACCE states that "the curriculum should be designed to accommodate continually expanding requirements of the profession, advancements in knowledge, and the contributions of related disciplines"[10].

Demolition and Reconstruction Course Development

Purdue University has, since the fall of 2005, offered two elective courses in demolition and reconstruction management. These courses use the demolition process to introduce students to ways in which existing structural systems impact the choice of demolition means and methods. Students also learn why demolition and reconstruction management decisions are heavily influenced by existing project characteristics rather than solely by design documents. Because a great deal of reconstruction activity is similar to new construction, a greater emphasis has been placed on the management of the demolition process in course development.

To help guide the selection of course content, the author conducted a form of group needs assessment specifically designed to identify the course topics that the demolition industry identified as necessary for students who would be hired in entry level management positions by demolition contractors[11]. The needs assessment was accomplished through a meeting of four members of the demolition industry who serve as an education committee of the National Demolition Association Board of Directors. This NDA advisory committee is made up of demolition company owners and senior managers from small, medium, and large firms operating in geographically diverse areas (Pacific Northwest, South, Midwest, and National). The meeting took place in September 2008 on the university campus to assure that business interruptions were kept to a minimum.

Table 1 includes the results of the process to identify demolition topics that should be included in the demolition and reconstruction plan of study. Many of the topics are covered in depth in the

core construction management curriculum at Purdue University. Some of the topics are covered in the core curriculum, but have specific demolition related content that must be augmented to fully prepare students for work in the demolition industry. There are also topics that are unique to the demolition industry and must be covered in their entirety by the demolition and reconstruction courses. The list is arranged in the rank order that resulted from the needs assessment process. Demolition topics that must be covered in their entirety are shown in **bold underlined text** and topic content that needs to be augmented by the demolition and reconstruction courses are shown in **bold text**.

Table 1
Demolition Topics Identified by Advisory Committee

Importance Rank	Topic Description	Construction Mgmt. Topic	Mixed Topic	Demolition Topic
1	Blueprint Reading and Take off	X		
2	**Safety**		X	
3	Measures/Weights/Volumes, etc.	X		
4	**Project Management**			X
5	**Basic Equipment Knowledge**		X	
6	**Estimating**			X
7	Contract and Business Law	X		
8	**Environmental Regulations**			X
9	Negotiation	X		
10	**Truck Haul Complexity**		X	
11	**Proposal Writing**		X	
12	CAD/Computer Skills	X		
13	**Material Disposal**			X
14	**Risk Management & Insurance**		X	
15	**Recycle and Salvage Sales**			X
16	Chemistry, Physics as they apply	X		
17	Document Management	X		
18	Building Types	X		
19	**Schedules**		X	
20	**Methods**			X
21	**Hazardous Materials**			X
22	**Permits and Disconnects**			X
23	Office Technology & Management	X		
24	Spanish language	Future?		
25	**Labor: Union vs. Non-Union**		X	
26	Dealing with non-English speakers	Future?		
27	**Writing Engineering Survey**			X
28	**Marketing**		X	
29	**Revenue Sources**		X	

Although necessary, this process is not sufficient to completely guide the curriculum. Many of the topics identified are specific to a single task such as “writing an engineering survey”. Others,

such as “project management” will require additional guidance to assure that course content is sufficient in both breadth and depth of the topic.

Demolition and Reconstruction Content Appropriate for All Construction Programs

While Purdue University has chosen to offer full courses in demolition and reconstruction, many universities will not have the necessary resources to implement as complete an offering in this subject area. This would not preclude the addition of demolition and reconstruction content in courses that are currently dedicated to new construction topics. The following content areas are suggested based on their relevance for all future construction managers and their appropriateness for inclusion based on current accreditation criteria.

Pre-job Planning and Hazard Identification – An engineering survey conducted by a qualified person is required on demolition projects by the U.S. Occupational and Safety Administration (OSHA) regulation[12]. This survey allows the demolition contractor to fully evaluate the project, become aware of potential hazards, examine public and employee safety issues, and collect data for planning the methods and materials to complete the job. Issues such as bracing and shoring, the need for temporary protective structures, dealing with environmental hazards and disposal, utility disconnects, fire protection, first aid services, and project site access are examined in detail during this survey. To appropriately manage the health and safety of their projects, construction managers charged with oversight of demolition activity as part of an overall construction project would be advised to obtain a copy of the demolition contractor’s engineering survey and have a working knowledge of checklists used to perform similar surveys.

Handling of Hazardous Material – One of the most expansive sections of the OSHA safety and health standards deals with the handling of hazardous materials. The U.S. Environmental Protection Agency (EPA) also has comprehensive regulatory oversight of potentially hazardous materials encountered in demolition and reconstruction activities. Some of the most commonly encountered hazards are asbestos, lead, and Polychlorinated Biphenyls (PCB).

Hazard Communication – Construction managers need to be aware of the unique material hazards present in demolition. In addition to assuring that the firms engaged in demolition activity on their projects have an appropriate hazard communication program, construction managers need to include these hazards in their own hazard communication program to inform all workers in the vicinity of demolition work of the potential for contact with hazardous material.

Personal Protective Equipment – Although personal protective equipment is not unique to demolition and reconstruction, the nature of the work requires some specialized knowledge to assure proper equipment selection and use. The extensive use of torch cutting requires both proper eye protection and respiratory protection. The release of lead fumes when torch cutting painted steel requires proper respirator selection, medical evaluation of workers who use the respirators, and a respirator maintenance program. Fall protection equipment selection, use, and maintenance are also important components for construction manager knowledge since demolition and reconstruction activity frequently exposes workers to unique height risks. Safety

nets, retractable lanyards, full body harnesses, and specialized anchoring systems may be required in addition to provisions for guard rails or other barrier type fall protection.

Safe Use of Hand Tools – Demolition and reconstruction frequently involves a form of material reuse called soft-stripping or non-structural deconstruction. Soft-stripping refers to the removal of specific building components that are determined to have a significant resale value. These components are removed prior to the demolition of the structure[13]. Common hand tools and manual labor are required for the removal and refurbishment of these materials. These tools are frequently used in a "forceful" manner, have sharp or abrasive surfaces, and are capable of significant human harm. Care must be taken to avoid the assumption that everyone knows how to use these tools. Construction managers should be able to select appropriate tools for the job, know how to use the tools in a safe manner, and assure that the tools are stored and maintained properly.

Safe Blasting Procedures – Although blasting is actually used in a rather small percentage of demolitions[2], explosives when used require careful planning, preparation, transportation, storage, and disposal. Safe blasting procedures are covered by a relatively large group of OSHA standards.

Safety When Working in Confined Spaces – Confined spaces in demolition and reconstruction include storage tanks, vaults, silos, utility tunnels, and vessels where natural movement is restricted, access is limited, and fresh air supply may be limited. In addition, these confined spaces may present flammable, toxic, corrosive, or irritating work environments. Construction managers must be aware of these hazards as well as appropriate communications, ventilation, monitoring, and rescue planning procedures for work in confined spaces.

Safe Demolition of Pre-Stressed and Post-Tensioned Concrete – Many modern reinforced concrete structures utilize steel reinforcement placed under tension either during the placement of concrete or immediately after concrete placement. These pre-stressed or post-tensioned structures are now reaching an age where demolition may be required. Since the steel reinforcement is in tension at all times, the demolition process presents the potential for the release of violent or explosive forces. Construction managers should be aware of the potential for this forceful release of tension and must assure that appropriate engineering advice and planning is obtained prior to demolition of pre-stressed or post-tensioned concrete.

Debris Removal and Falling Debris – Removal of debris is a major component of demolition. The large quantity of material that must be moved from upper floors to the ground level presents the potential for impact damage to structures from falling debris, generation of potentially hazardous dust, danger to workers below debris removal activity from falling items, potentially unsafe cutting of floor openings for debris drop locations, and the improper use of debris chutes. OSHA regulations for demolition provide some guidance for construction managers in oversight of demolition debris removal operations.

Competent Person – OSHA regulation requires that a competent person continuously inspect the progress of a demolition project to detect potential hazards from weakened structures, inadequate shoring, lack of bracing, or other hazards from unexpected conditions. Since no employee should

be allowed to work while an unsafe condition exists, construction managers should be aware of the authorized competent person and recognize that the designated competent person can and will stop work in the event they judge an unsafe condition to exist.

Public Health Hazards – Demolition and reconstruction activities have a high potential for impact on the health of the general public. These activities are commonly conducted in close proximity to occupied spaces, often in high-density urban settings. Consequently, the public is likely to be exposed to an assortment of dust and debris that results from the dismantling processes. Both airborne and waterborne contaminants released by demolition or reconstruction dismantling have the potential to expose large populations to significant health hazard.

Dust is generated in large quantities during demolition activities. Dust control must be provided to minimize the nuisance of dust exposure for surrounding properties as well as the health hazards created by the dust. Some demolition and reconstruction projects can expose special populations, such as the elderly and individuals with compromised immune systems, to health hazards that require even greater care. Histoplasmosis is an infectious disease related to dust control. The disease is caused by spores of a fungus and can create a chronic lung disease that resembles tuberculosis. Although the disease is not contagious and cannot be transmitted from person to person, the spores are frequently found in areas frequented by birds and bats in buildings[14]. Inhaled dust generated by demolition or reconstruction activity can become a vehicle for the transmission of the spores. Workers should exercise care when working around bird or bat droppings.

Inadvertent exposures to environmental pathogens such as aspergillus and legionella or airborne pathogens including mycobacterium tuberculosis and varicella-zoster virus can result from dust transfer during demolition and reconstruction activities in occupied health care facilities. Environmental infection-control strategies and airflow controls can effectively prevent these infections. After performing an infection control risk assessment (ICRA), the multi-disciplinary team formed to manage infection control during healthcare construction activity creates a proactive plan of action. Infection-control measures typically include creating a negative air pressure condition within the spaces undergoing demolition or reconstruction activities to prevent contaminated air from leaving these spaces through uncontrolled ventilation. Air removal from the construction areas is through HEPA filtration, preferably exhausted to the exterior[15]. In addition to creating and monitoring negative air pressure in the construction zone, the infection-control plan will require extensive containment procedures. Containment procedures include sealing all connections with the ventilation system, installation of dust control partitions of either hard walls or plastic film barriers, controlled access to and from the construction area, and limitations on construction traffic through unaffected portions of the building.

These procedures illustrate ways of meeting the need for dust control that provides infection-control in conditions where severe public health conditions exist and enforcement is common within the facility. It is strongly suggested that similar dust control measures be utilized for any demolition or reconstruction activity within or adjacent to an occupied space. Not only will adoption of these measures prevent the spread of dust borne contaminants, it will minimize the nuisance and disruption created for the occupants.

Demolition and reconstruction also produces a significant quantity of debris. Handling and disposal of this debris have the potential to impose both short-term public health exposure and long-term environmental pollution. Products exist in the demolition waste stream that contain small quantities of materials which are hazardous to public health. These materials, when concentrated in a landfill, create a potential for environmental contamination through leaching of the hazards into the groundwater.

Listed below are some common products removed during demolition and reconstruction, along with the related hazardous material found in these products. These products should be removed from the demolition waste stream through diversion to appropriate recycling programs or proper disposal in a hazardous waste facility:

- Fluorescent Light Bulbs – Mercury
- High Intensity Discharge Lamps – Mercury
- Thermostats - Mercury
- Silent Switches – Mercury
- Lighting Ballasts – PCBs & di (2 ethylhexyl) phthalate (DEHP)
- Batteries – Lead, Mercury, & Cadmium
- Flashing & Pipes – Lead
- Treated Wood – Arsenic
- Refrigerants – Chlorofluorocarbons
- Smoke Detectors – Radioactive Materials

Demolition Regulatory Environment **–** Demolition and reconstruction projects frequently present risks that new construction projects do not. These risks may impact workers, the general public, neighboring property owners, and the communities in which the projects reside. These risks can include a wide range of threats including but not limited to public health dangers, economic impacts, environmental hazards, aesthetic concerns, and even emotional reactions. Consequently the regulatory environment for demolition and reconstruction is complex, variable by community, and in many cases restrictive. As construction managers become increasingly exposed to demolition or reconstruction as a component of the project, their knowledge of the regulatory environment must be expanded beyond typical new construction model codes and permitting. In addition, since demolition is frequently conducted without the guidance of a design professional, demolition requires the construction manager to take full responsibility for regulatory compliance.

Sustainable Practices in Demolition and Reconstruction **–** Sustainability and 'green' attributes of projects are becoming increasingly important to project owners. The U.S. Green Building Council (USGBC), the originator of the Leadership in Energy and Environmental Design (LEED) building certification program, points out that although green building activity represented only 2% of the non-residential building market in 2005, current trends indicate that this percentage will grow to 20-25% by 2013[16]. Demolition and reconstruction can and will play a major role in green certification programs due to the contractor's ability to influence reuse and recycling of materials that are a byproduct of these projects. As construction education programs

embrace sustainability in their curriculum, the demolition project management decisions that play a role in green certification will be a logical topic area to include.

Available Resources for Demolition Course Content

Through the work of the membership and board of directors of the NDA, the demolition industry has been proactive in the development and dissemination of health and safety training material that can be utilized by construction education programs. The NDA health and safety publications include, the *Demolition Safety Manual, Hazard Communications Program, Demolition Talks, Lead Safety in Construction, Lead in Demolition Work an Employer (Employee) Manual, Demolition Preparatory Operations, Skid Steer Safety Tips, Site Specific Safety Plan Guidelines*, as well as checklists for safety meetings, job-site safety hazard assessment, competent person designation, utility disconnect survey and follow-up. Safety videos are also available from the NDA for general demolition safety training, lead safety awareness, and safe skid steer operation.

A textbook titled *Demolition: Practices, technology & management* will be published by Purdue University Press in late 2010 to serve as a primary resource for introduction to demolition at the college level. Written by a consultant to the demolition industry and the author of this paper and based on the experience of offering the first college level management courses in demolition, this new book will include chapters covering the following topic areas:

- Introduction to the Industry
- The Demolition Contractor
- Modern Demolition Practices
- Types of Demolition – Buildings & Structures
- Demolition Regulatory Guides
- Estimating
- Contracts and Accounting
- Safety
- Demolition Equipment
- Material Handling and Recycling
- Explosives in Demolition
- Disaster Response
- Project Management

Demolition contractors can also be a valuable resource for course content. With the help of the education committee of the NDA, Purdue University has utilized guest speakers from the demolition industry to provide valuable classroom experiences for students. These guest speakers have been especially helpful in providing relevant information about proper management of demolition contractors who are hired as subcontractors. By pointing out potential conflicts between demolition and new construction as well as the management requirements of demolition activity not experienced in new construction, these speakers help to inform students and faculty about critical demolition practices. They also emphasize the special knowledge a general contractor should possess to effectively manage demolition as an element of a new construction project.

Purdue faculty also utilized demolition contractors to prepare for teaching in an area where their experience was limited. During several summers and throughout the school year, demolition project visits enabled the author to expand his knowledge of the types of demolition encountered, common demolition techniques utilized, typical equipment used, project management challenges experienced, project planning needs, available checklists to assist the manager, regulatory requirements, material handling issues, safety issues, and many common business practices of the demolition industry. Many classroom resources resulted from these project visits. Videos were taken of the project activities being observed whenever possible. These videos were edited to show one or more salient points about the project, the demolition techniques used, or the management of the process. Photographs were taken when video was impractical. Project visits also provided valuable interaction with members of the demolition industry. The time spent with multiple practitioners provided a variety of perspectives to help the author understand the special management requirements of demolition activity.

Conclusion

In response to the aging of the built environment in the United States, demolition and reconstruction activity will continue to grow. It is logical to conclude that as a result a greater percentage of construction professionals will include theses activities as construction services they provide and manage. The construction managers and engineers of the future will need to gain a familiarity with the unique challenges created by demolition and reconstruction as part of their construction education. This familiarity will help avoid the potential threat to company performance, the environment, public and employee safety, and possible violation of regulatory requirements that comes from a lack of knowledge and preparation. To better prepare students for these future needs, it is suggested that the curriculum of every post-secondary construction education program include demolition specific material. At a minimum, demolition related topics as they apply to employee and public health, the regulatory environment, sustainability, and project management should be a part of the construction curriculum. Preparing graduates to use the existing built environment as a major element in project decision making when appropriate should be part of the curriculum as well.

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