122nd ASEE Annual Conference & Exposition
June 14 - 17, 2015
Seattle, WA
Making Value for Society
Paper ID #13471

An Online Course and Teacher Resource for Residential Building Codes and Above Code Construction Methods

Dr. Tripp Shealy, Virginia Tech

Tripp Shealy is an Assistant Professor of Civil and Environmental Engineering at Virginia Tech.

Miss Audra Ann Kiesling, Clemson University

Audra Kiesling is a Ph.D. Candidate in the Glenn Department of Civil Engineering at Clemson University.

Mr. Timothy R. Smail, Federal Alliance for Safe Homes

Tim Smail, Senior Vice President – Engineering & Technical Programs A results-driven professional, Tim has extensive educational, project management and research experience in disaster mitigation building practices. Tim leads the research and technical aspects of signature FLASH programs including the professional training program Blueprint for Safety. Tim is also the key collaborator with the National Voluntary Organizations Active in Disaster to embed mitigation information into the long-term rebuilding process. Tim is a member of the Advisory Committee for the National Science Foundation –Science Master's Program (NSF-SMP) in Resilient and Sustainable Infrastructure in the Clemson University Civil Engineering Department and the Florida International University Wall of Wind (WoW) Technical Advisory Committee. Tim holds a BSEE from Penn State University and a MSEE from Georgia Institute of Technology.

An Online Course and Teacher Resource for Above Code Construction Methods

Community destruction and loss of life due to residential building code violations still occur too frequently and increasing code enforcement is often not possible due to lack of funds and resources. Teaching the International Residential Code (IRC) to college-level construction students is another way to encourage greater code compliance and enhance community resilience. In a national curriculum review of construction management, architecture, and civil engineering programs (2-year, 4-year, and graduate degrees, 950 in total), only seven percent provide courses with IRC related learning outcomes. A follow-up national survey to construction, architecture and civil engineering faculty suggests the barriers to teach codes are the lack of available resources and low cognitive student learning perceived in teaching about the IRC. In response to these findings an online course was developed. Students learn how codes will influence their professional careers, identifying the difference between prescriptive and performance based codes and communicating how codes relate to the performance of a structure. Student learning outcomes are created through multiple active learning methods. For example, house plans are distributed to students, and in a problem-based approach, students “red line” drawings to meet the IRC. In a case-based module, students identify solutions to grey-water systems that do not meet current local codes. Course modules were developed with an advisory committee including building code officials, architects, construction managers, disaster mitigation experts, and academic faculty. Advisory members anonymously submitted feedback for each module. Feedback was compiled, discussed and course content edited. This review-discuss-edit process was repeated until a final version was agreed upon with the advisory committee. The course and content is a free resource for educators. Over thirty modules, house plans and videos of industry professionals are embedded within. Modules can be delivered in a semester long course but can also stand-alone. Course link: canvas.instructure.com/courses/780681.

Introduction

Municipalities lacking International Residential Code (IRC) adoption or inadequate enforcement risk greater chance of community destruction during the event of a natural disaster. For example, the investigation by the California Seismic Safety Commission into the Northridge southern California earthquake found far less destruction would have occurred if building codes had been rigorously enforced[1]. Municipalities lacking enforcement cite deficient funds and resources as the cause[2]. The current economic environment (especially at the local government level) limits the amount of adequate funding available to improve building code enforcement. The future safety of communities will require a different solution.

Educating the next generation of building professionals regarding building codes, specifically residential, is one potential solution for safer communities. Students majoring in architecture, civil engineering, and construction science will soon become responsible for following building code regulations. These students must accept responsibility and potential liabilities associated with their services. There is a current lack in connecting building science to codes and code implementation[3]. Teaching about the IRC can encourage greater code compliance in the future.

With nearly 90 percent of Americans living in locations that place them at a moderate-to-high risk for earthquakes, volcanoes, wildfires, hurricanes, flooding, or high wind damage[4] there is a strong need for societal resilience in the context of natural hazard risk beginning with systemic integration of resilience in education[5]. When rebuilding after Hurricane Katrina, New Orleans city officials encouraged homeowners to rebuild in the same areas in which the flooding occurred, effectively leaving resiliency in the hand of the construction professional performing the work. Building back stronger is only possible when these construction professionals understand how to do so. Professionals who believe the IRC is valuable knowledge are more likely to implement codes into their work even when not required or enforced by law. A portion of learning to build back stronger includes educating to the IRC. Understanding the current status and best practice for teaching students majoring in architecture, civil engineering, and construction science management (here in after known as "construction students") about the IRC provides the first step to mitigating communities in the future [6].

Background

A literature review for teaching about the IRC produced no new publications since the early 2000's when the International Code Council (ICC) was formed and states began adopting versions of the IRC. Prior to the ICC, research publications discussed the difficulty in code integration to the curricula due to numerous code agencies, state policies, and conflicting codes. Much of the publications speculate IRC education will improve, becoming inherently easier to teach, when the IRC becomes the prevailing code [7].

The more than decade long deficiency in IRC education research and lack of IRC teaching method information presents the question, why is there a gap in literature that began when the IRC commenced? One idea is that construction programs believe IRC is now taught properly because there is only one code and requires no additional research or discussion. Another suggestion is that teaching prescriptive codes like the IRC holds little importance in curricula and therefore is not a research priority. A report from the *Journal of Energy Design Update* (2005) presents a conflicting argument suggesting schools are not providing sufficient education regarding building science and code compliance. The concern that IRC is not addressed in construction education is the starting point for which this research provides insight to restart the conversation about IRC education.

Objective

Teaching building codes to the next generation of construction professionals may result in greater code compliance impacting community resilience. This research addresses current university construction program curricula. Initial survey results are used to guide the development of a building code course for undergraduate and graduate students.

The research objectives are to (1) assess the current status of residential building code education in accredited architectural, civil engineering, and construction science management programs; (2) identify "best practice" for IRC teaching methods and current academic and industry perspectives of teaching IRC; and (3) develop content, materials and resources to support teaching the IRC.

Methods

The mixed-method research approach included three phases. Every curriculum of every program with a student chapter of American Society of Civil Engineers (ASCE), Construction Science Association (CSA), and American Institute of Architects (AIA) was reviewed for courses related to residential building codes. Faculty members within each department from phase one were asked to participate in the phase two survey about teaching building codes. Recommendations from the survey guided the development of a residential building code course in phase three.

Approximately 950 different programs throughout the country, ranging in degree types from associate degrees to PhD programs, were reviewed. These degree programs represent 460 university departments. Curriculums were accessed through online department websites, course outlines and course descriptions. Any course with a description related to the IRC was marked as teaching about residential codes.

Faculty members within each department from phase one were asked to participate in the survey. Survey questions varied between multiple choice, order ranking, Likert scale, and open-ended. Analysis included frequency distribution of responses, percentages, frequency of terms in open-ended responses, and ranking. An email asking for participation was sent to approximately 400 faculty members who teach construction related courses. Members of the American Institute of Architects (AIA) Residential sector and the International Code Council (ICC) were also asked to participate in a similar survey. Survey questions asked if and how IRC should be taught and to rate the value of teaching IRC compared to other topics.

The academic response rate was 15 percent (68 participants) with a completion rate of 79 percent (54 completed surveys). Civil engineering faculty represent the majority of university programs across the country and were the largest survey respondent group. In total, 90 ICC and AIA members started the survey with a completion rate of 86 percent (77 completed surveys).

Recommendations from survey results guided the development of the residential building code course. An advisory committee of professional engineers, architects, and building code officials oversaw course development. Course content and delivery was checked using face validity with students and trained online course developers. Further explanation of course development methods is explained in a later section of the paper.

Survey Results

A national curriculum review of construction management, architecture, and civil engineering programs (2-year, 4-year, and graduate degrees, 950 in total) identified only seven percent of courses provide residential code related learning outcomes. A follow-up national survey to construction, architecture and civil engineering faculty suggests the barriers to teaching codes are the lack of available resources and low cognitive student learning objectives perceived in teaching the IRC.

Both industry and academia believe the topic of IRC is valuable to students' career success and should be taught. Industry professionals cite "on-the-job" training as ways in which they learned the IRC and over 90 percent of industry participants agreed the IRC should now be taught within degree programs prior to industry experience. The majority of faculty surveyed also agreed the IRC should be taught. At minimum, students should understand the "bigger-picture" of how IRC will influence their careers and display proficiency in recognizing IRC compliance. Survey participants suggest the most appropriate time to teach IRC is after students learn design principles. This is typically at the beginning of year three of four-year programs or second year of two-year programs.

The surveyed faculty indicated free and available course modules would encourage them to include IRC related content in their current courses. The faculty also indicated student resources on how to navigate the IRC as beneficial to student learning. Varying levels of detail are needed to span associate, undergraduate, and graduate level course work. Modules should include a basic understanding, with varying degrees of knowledge regarding code implementation. Survey responses varied for best teaching practices. Multiple techniques should be incorporated including case studies, lectures, and project-based learning.

Industry professionals concluded that the IRC is relevant to degree programs and beneficial for a career in civil engineering, architecture, and construction science. Faculty would be willing to include IRC information into course work if teaching materials were available. The survey results identify a need within the construction community and a gap in education. The next phase is acting to correct this knowledge gap to improve the IRC education. Course development may lead to more acceptance and practice of IRC in construction programs.

Course Introduction

In response to these findings an online course was developed. Students learn how codes will influence their professional careers through identifying the difference between prescriptive and performance based codes and communicating how codes relate to the performance of a structure. The intent of the course is not for students to memorize code. Students should be able to explain why codes are adopted, how to change them, and when to build above code minimums. Course modules incorporate technical illustrations, videos describing building material, and installation procedures. Assignments include a case-based dilemma on grey-water systems that does not meet code. Students interpret the intent of the code and identify how to change either the grey-water system or how to rewrite the code to include grey-water use. The course culminates in a problem-based assignment. Students redline drawings to specific disaster mitigation techniques against regional natural hazards.

The content is free for educators and students. Over thirty modules, house plans and videos of industry professionals are embedded. Modules are deliverable in a semester long course but can also stand-alone. Course content exposes students to the IRC as the minimum accepted building practice. The target audience is undergraduate and graduate level students enrolled in civil engineering, architecture or construction science management programs.

Course Development Methods

Course modules were developed with an advisory committee. The committee was selected based on number of years in professional experience, professional certifications, and current service to industry organizations. The committee included building code officials, architects, construction managers, disaster mitigation experts, and academic faculty. All with ten plus years of experience and currently serving on advisories boards related to building codes or resilience in construction practice.

The advisory committee listened to a presentation of the survey results and was asked to respond to the findings by anonymously submitting a list of educational objectives for students desiring a career in residential construction. The individual lists were complied into categories. Modules were developed based on each category and each module was divided into a series of lectures and student objectives. The advisory committee reviewed the lecture objectives, modules, and categories before content was developed.

A sub-committee of construction professionals and graduate students developed the lecture content. Once lecture material and assignments were developed, the advisory committee would review and suggest changes. This develop-review-edit process occurred approximately twice for each lecture. Review comments ranged from technical content to lecture presentation, for instance, updating to the most current wind maps or re-recording videos of professionals on a construction site.

Technical objectives, such as means of egress and roof assembly, were grouped together under "Construction with the Code in Mind" module, while objectives like how to explain prescriptive and performance based code and defining the risks associated with building in a high wind zone were included in a module to bridge code application and implementation. In total there are 5 modules and 30 lectures. Lectures vary in length and detail. Each lecture includes an assignment and discussion question. Discussion questions are meant to engage students in a learning community. Often students must respond to another student's discussion post.

Graduate students were enlisted to review the final course and provide feedback. The comments focused on delivery, student discussion questions, and homework lengths. A third party, online course developer, then reviewed the course. The feedback focused on formatting and ability to access content, links (e.g. video, slides, websites). A similar review-edit process was used with the third party reviewer.

The developed course was reviewed and approved for distribution by the International Code Council and supported by FEMA's building science division. A subject matter expert in law familiar with building codes and the code development process reviewed the course. Opinion based feedback insured content is not overstating code intent and approved for reproduction. These course development methods were followed to ensure course content and delivery is appropriate for free release and distribution to other universities and organizations. We expect further edits and changes as construction faculty begin downloading and using the content.

In all, over twenty professionals and graduate students helped develop course content, student assignments, and the online format. We followed a develop-review-edit process with the advisory committee, graduate reviewers, and third party online course developer. The modules cover technical code specific requirements and also why and how codes are written. Students connect this information to disaster risk through homework and discussion assignments.

Course Content and Delivery

Students who complete the course should be able to explain the purpose of the IRC and when to build above IRC prescriptions. The course is not meant for students to merely read the IRC manual and memorize code specifics, but to prepare them to discuss code implications and reasons for above code construction. The course is composed of five modules: (1) Introduction; (2) A Code Review; (3) Construction with the Code in Mind; (4) Code Application and Implementation; and (5) Does Code Equal Resilience. The beginning modules explain how building codes continue to evolve. Students then learn about the IRC and code specifics. By the end of the course, students will have the chance to adjust the price of a home based on above code construction methods and describe how these above code practices impact the resiliency of a dwelling against natural disaster. Student will debate the increased cost of the home compared to the reduced risk during a natural disaster.

Learning objectives are based on the advisory committees initial list of needs for college students entering a career in construction related fields. The large themes of student objectives are stated below.

Students should be able to:

1. Recognize the purpose of residential building codes and standards.
2. Understand how residential building codes are adopted and enforced.
3. Identify the difference between prescriptive and performance based codes and standards.
4. Communicate how residential building codes relate to the performance of a structure.
5. Justify the benefits of building to code and beyond-code.

The course meets both ACCE and ABET student outcome objectives. Students must design a residential dwelling with realistic constraints of the IRC, which aligns with ACCE's objective to analyze construction documents for planning and managing construction and ABET's student outcome C, to design a system to meet desired needs. Students will practice written and oral communication explaining benefits of above code construction. This aligns with ACCE's statement to create written communications appropriate of the construction discipline and ABET's student outcome G, ability to communicate effectively. Students will broadly assess economic benefits of above code construction, which meets ABET outcome H, a broad education necessary to understand the impact of engineering solutions.

Example Assignment

Assignment – Part A

Use the flood-proofing estimator to identify the cost of each design option. This includes an estimate for building the home on fill (all fill, raising site elevation 12" above freeboard), posts, flood shields, and floodwalls.

- Is fill the cheapest option? By how much?
- What would be the cost if the building inspector did not catch the BFE mistake described in the Garza's story and the house had to be lifted with piers or posts installed after completion?

Assignment – Part B

Now, read FEMA's report of Hurricane Ike.

- What was the cost of housing damage?
- How many homes does this account for? What is the loss per home?
- What would have been cheaper: the insurance company to raise each home (if the average cost was similar to the Garzas) or pay the loss in damages?
- How long did the recovery from Hurricane Ike take?
- When did people return to their homes, rebuilding take place, and life return to normal? Can you put a price on that?

Example Discussion Question

Discussion Question – Part A

The module prior to the discussion question introduces students to grey-water systems and how some current local codes do not allow for reuse of grey water (i.e. wastewater generated from sinks, showers and baths). A case study is presented that follows two homeowners, Allen and Woelfle-Erskine, who build their own grey-water system without permission from the local code. In the article, Allen and Woelfle-Erskine are referred to as the grey-water guerrilla builders.

The discussion question part A asks, "What would Allen and Woelfle-Erskine need to do to change the residential building code in their local community to allow their grey-water system? Who would they need to convince? Are guerrilla builders still needed? Or is there a procedure in place to better promote future code changes in a local community?

Example student responses to the discussion question part A:

> Student A: Watershed and wastewater contribute to large amounts of recyclable water for exterior use. But in order for Allen and Woelfle-Erskine to change the local building code to allow their grey-water system, they have to design an efficient patent for the intricate system they propose. Their idea, use, and effect of reusing grey water has a high impact to sustainability, but lacks the structure of a system to remove the grey-water from the home and transition it to exterior containers, irrigations, and cleansing drains. They need the aid of an innovator to stabilize and implement an acceptable system's design in order to further the possibility of creating an extension of the uses of grey-water by code. Once an acceptable system is established, the local government is all that is needed to be convinced, with no need for any more guerrilla builders.

> Student B: Allen and Woelfle-Erskine need to at first come up with a slightly more qualified system as opposed to bathtubs. The idea is great of course, but working with a company like Rewater might be a good place to start in developing a cheap system that isn't $7,000, but is slightly more defined than pvc pipe into tubs and barrels. After they come up with a solid system then they should look into applying to change the code in whichever way their local community states that is necessary. This along with evidence of their new system

> would be optimal for the new code to pass. They need to convince the local authorities of code that this can help in a number of ways as opposed to the current systems. I don't know if Guerrilla Builders are necessary, but there is always a need for people to challenge the norm and see if they can make something better or approach it differently.

Discussion Question – Part B

Students were then asked to identify an area of the IRC that they think should be changed and post it to the discussion page. After posting, they need to respond to two of their classmates' posts and explain whether they agree with their suggested change or not, and why.

Example student response to discussion question part B:

> Student C: The use of green wire nuts on a ground wire connection should be removed from the code, as the ground wire serves as a safety feature in grounded out electrical surges a home may experience. The ground wire is a naked copper wire that is never intended to carry an electrical load other than to take an electrical surge directly to the ground, preventing an electrical fire. Tying/splicing a number of these wires together by twisting them together is the same as having them all tied together in a green wire nut. The color and use of a specific wire nut is an unnecessary part of the general National Electrical Code.

> Student D response to Student C: I disagree with the change because the ground wire may not be naked copper in all cases, which could lead them to be mistaken with hot and neutral wires. A color specific wire nut is a good way to make sure the grounds stay together.

> Student E response to Student C: I agree with [Student C] as there is no need for a color specific nut. The wire itself serves no purpose other than to ground. However if there was the possibility of another copper wire to be installed within a certain distance the use to specify the copper would be necessary, but in my experience your ground wire is clearly shown and is not in anyway confused for something else.

Conclusion

A construction course on IRC implementation was identified as a worthwhile investment to increase education for construction students on code and above code construction methods. Both faculty and industry believe this topic should be addressed during the second half of undergraduate and graduate programs. An advisory committee was formed and learning objectives for the course were outlined. The course modules include a basic understanding of the IRC, how to change them, and when construction methods should go beyond code recommendations. Assignments include case studies and problem-based learning. House plans are provided and students modify house drawings through each phase of the course. Course content is free and can be downloaded as a teacher resource, a full length course, or student aid during a design project. Course link: canvas.instructure.com/courses/780681.

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