VIRGINIA TECH™

Digital Standards Education Modules for Innovation and Sustainability of Concrete Infrastructure

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Project Summary

To include standards education in civil engineering curriculum for concrete and cementitious materials through digital learning modules including video lectures, virtual field trips, exercises, and other resources to introduce undergraduate and graduate students to current and emerging trends related to materials, sustainability, emerging and future technologies, and the resiliency of the built environment.

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- Ph.D., 2015, Civil Engineering, University of Illinois, Urbana, IL
- NRC Postdoctoral Research Associate, 2016-2018, Engineering Lab, NIST, Gaithersburg, MD
- Assistant Professor, 2018-Present, Civil and Environmental Engineering, Virginia Tech
- Research: Cement and concrete composites, micro- and nanostructure, advanced characterization techniques, cement chemistry

PI: Eric Jacques, Ph.D., P.Eng.

- Ph.D., 2016, Civil Engineering, University of Ottawa, Ottawa, ON
- Assistant Research Officer, 2015-2017, Civil Engineering Infrastructure Group, National Research Council of Canada, Ottawa, ON
- Assistant Professor, 2017-Present, Civil and Environmental Engineering, Virginia Tech
- Research: Reinforced concrete structures, physical infrastructure security, blast resistance

PI: Roberto T. Leon, Ph.D., P.E.

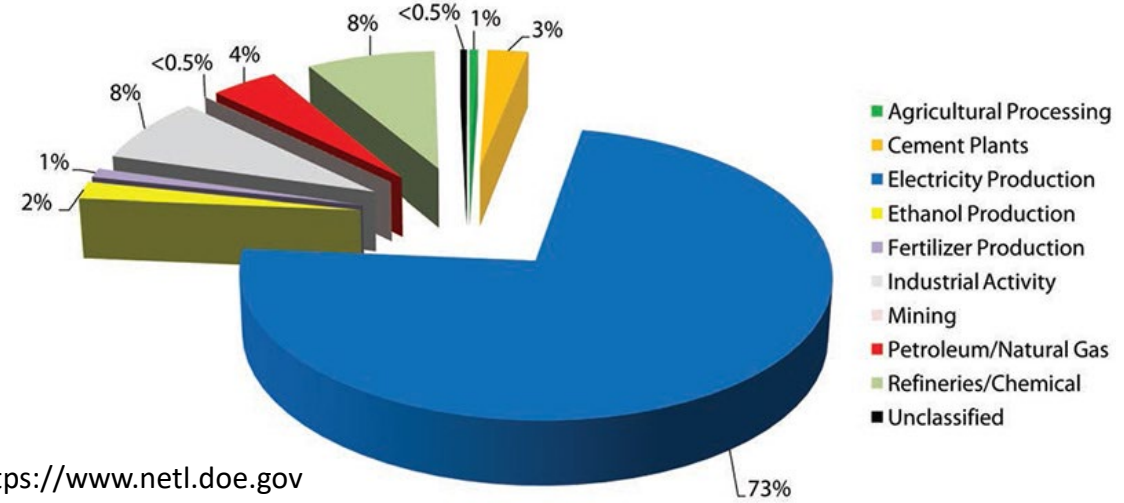
- Ph.D., 1983, Civil Engineering, University of Texas, Austin, TX
- Professor, 2012-Present, Civil and Environmental Engineering, Virginia Tech
  - University of Minnesota (1983-1994)
  - Georgia Tech (1995-2011)
- Research: Behavior and design of steel and composite connections, seismic design, seismic behavior of bridges
- Distinguished Member, American Society of Civil Engineers (2016)

Project Motivation

- ASCE grades America's infrastructure as **D+**
  - $3.9 trillion to the U.S. GDP by 2025
- Concrete is a critical infrastructure material
  - 4 billion tons of portland cement per year worldwide
  - 27.5 billion tons of concrete per year worldwide
- Production of 1 ton of portland cement releases **0.7 to 1.1** tons of CO_2
  - 5-8% of global anthropogenic CO_2
  - 3rd largest CO_2 producer

https://www.djc.com/news/co/11194205.html

CO_2 Stationary Source Emissions by Category

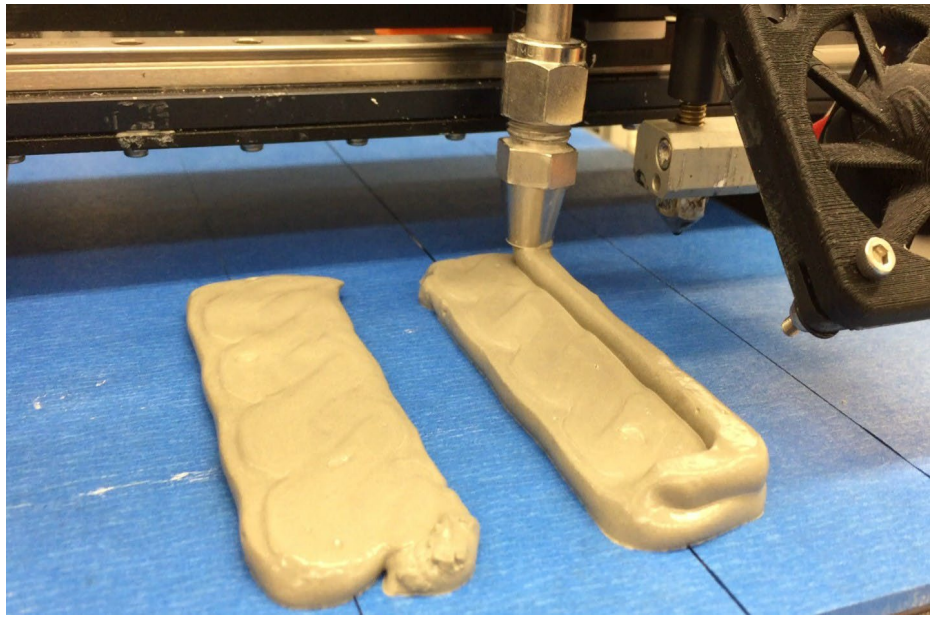


https://www.netl.doe.gov

Project Motivation

- Preparing students for the future of the cement and concrete industry
  - Trends in sustainability (CO_2 reduction)
  - Evolution of current and future technologies, such as 3D printing
  - Performance vs. prescriptive standards
  - Innovations in materials for performance and resiliency

Alex Brand, VT



Scott Jones, NIST

Project Description: Modules

1. **Cements and Structural Concrete Module**
   - Importance and role of standards in the industry
2. **High Performance Concrete (HPC) Module**
   - Standards for current and future trends in HPC
3. **Cement and Concrete Sustainability Module**
   - Role of standards in the future of concrete within the framework of sustainability
4. **Future of Concrete Design and Manufacture**
   - Evolution of standards for future technologies and trends

Module Development

- Assistance from Virginia Tech's Technology-enhanced Learning and Online Strategies (TLOS)
- Implementation in Canvas with public release and access
- Each module will be designed to be completed in 6 to 8 hours
  - Content: video lectures, reading assignments, virtual field trips, quizzes, capstone activities, short answer and reflection, and other resources
- Inherent "plug and play" nature of the multimedia components
  - Allows flexibility for instructors to use part or all of module content
  - Complete part or all of content as assignments or instructor-led discussion over a span of days, weeks, or even months
- Compliance with the Americans for Disabilities Act
  - Working with TLOS and VT Office for Equity and Accessibility

Implementation Plan and Piloting

Semester	Description
Fall 2020	• Curriculum material development for Modules 1 and 2
Spring 2021	• Initial piloting to two VT undergraduate courses (~170 students) • Curriculum material development for Modules 3 and 4
Summer 2021	• Curriculum revision based on Spring 2021 program evaluation
Fall 2021	• Second piloting to VT undergraduate and graduate courses (~220 students) • Piloting to two West Point undergraduate courses (~40 students) • External evaluation
Spring 2022	• Curriculum revision based on Fall 2021 program evaluation • Public release, reporting, and communication • ACI/PCA Professor's Workshop and ACI Committees E701 and S802

Short- and Long-Term Goals

- Short-term goals (12-24 months)
  - Undergraduate and graduate students at Virginia Tech and West Point (~450 civil engineering and building construction students every academic year)
  - Internal and external evaluations (students, academia, industry)
  - Public release of modules for use
  - Reporting and communication of the program
- Long-term goals (2-5 years)
  - Implementation of modules in multiple courses at VT
  - Dissemination of the program to national and international programs
  - Refinement of module content based on feedback

Evaluation Plan

- Anonymous assessment surveys to all students
  - Virginia Tech Center for Excellence in Teaching and Learning
- Likert-scale questions (e.g., strongly agree to strongly disagree)
  - Quantitative information on student perceptions of the instructional effectiveness, usefulness of the pedagogical components, and quality of the learning modules
  - Student learning outcomes – measured through graded work products and anonymous assessment surveys – will be mapped to the program curriculum to identify how and where standards and standardization outcomes are introduced, reinforced, and emphasized
- External evaluation by academic and industry professionals

Deliverables

1. Four digital learning modules that will be freely available online;
2. Instructional materials (e.g., suggestions for homework assignments, quizzes, and capstone projects) available by request to educators interested in implementing the modules;
3. Final report that outlines the module content, student and reviewer feedback, and impacts;
4. Journal article that summarizes the report and will be submitted to a peer-reviewed publication; and
5. Presentations that summarize the report and findings.

Dissemination of Project

- Reaching national and international audience
  - ACI/PCA Professor's Workshop presentation in 2021 or 2022
  - Presentation ACI Committees E701 and S802
  - Other education committees (e.g., RILEM Educational Activities Committee)
- Public release of information in a final report and a journal article
- Audience: students, academics, industry, professional societies
  - civil engineering, architecture, architectural engineering, construction management, and materials

Courses Impacted

- CEE 3684: Civil Engineering Materials
- CEE 3424: Reinforced Concrete I
- CEE 4614: Advanced Structural Concretes
- CEE 5484: Concrete Microstructure
- Other concrete courses at VT
- Reinforced concrete courses at West Point