A Winning Combination:

PCI Big Beam Competition and ASCE *Civil Engineering Body of Knowledge* Outcomes

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A bachelor of science degree in civil engineering is the typical educational pathway to a career in bridge engineering. In the latest draft of the third edition of *Civil Engineering Body of Knowledge*, the American Society of Civil Engineers (ASCE) defines the Civil Engineering Body of Knowledge as a "set of knowledge, skills and attitudes necessary for entry into practice of civil engineering at professional level."[1] For the *Civil Engineering Body of Knowledge*, ASCE describes 21 outcomes, grouped in four categories (see **Table 1**).

The typical civil engineering program is designed to introduce students to multiple branches of civil engineering. As a result, the typical bridge engineer has taken at least one course in environmental, transportation, structures, geotechnical, hydraulics, and surveying. The foundational and engineering fundamentals categories typically consume the first two years of an undergraduate degree. The breadth of engineering (the technical category) is introduced through upper-level requirements in the second two years.

Comprehension of the breadth of civil engineering is of course important, but engineering students are left with little time in their fully packed schedules for exposure to professional and technical topics specific to bridge engineering. Students must take specialty topics, such as prestressed concrete, in their discipline of choice as electives. In smaller academic programs, specialty topics may be offered only every other year, further limiting choices for students. Therefore, students wanting to prepare for a career in bridge engineering are left to seek other pathways for gaining discipline-specific knowledge.

Table 1. Selected *Civil Engineering Body of Knowledge* Outcomes

Category	Outcomes (partial list)
1. Foundational	Math, science, humanities
2. Engineering fundamentals	Materials, engineering mechanics, experimental, critical thinking
3. Technical	Project management, breadth in civil engineering, design, technical depth
4. Professional	Communication, teamwork, lifelong learning, professional attitudes and responsibilities

Source: Based on Appendix F of the 3rd edition of *Civil Engineering Body of Knowledge: Preparing the Future Civil Engineer.*

Table 2. *Civil Engineering Body of Knowledge* Typical Pathways for Outcome Achievement

Pathway	Description
Undergraduate education	Undergraduate education leading to a bachelor's degree in civil engineering or a closely related engineering discipline, generally from a four-year ABET/EAC-accredited program
Postgraduate education	Postgraduate education equivalent to or leading to a master's degree in civil engineering or a closely related engineering discipline, generally equivalent to one year of full-time study
Mentored experience	Early-career experience under the mentorship of a civil engineer practicing at the professional level, which progresses in both complexity and level of responsibility
Self-developed	Individual self-development through formal or informal activities and personal observation and reflection

Note: ABET = Accreditation Board for Engineering and Technology; EAC = Engineering Accreditation Commission.
Source: Based on the 3rd edition of *Civil Engineering Body of Knowledge: Preparing the Future Civil Engineer.*

The *Civil Engineering Body of Knowledge* outlines pathways to attain civil engineering competence at the professional level. **Table 2** shows that students and early-career engineers are expected to supplement formal education with mentored experience and self-development. Industry competitions such as the PCI Big Beam Competition are one way to incorporate both the mentored experience and self-development pathways to provide students with professional education in a specialty topic such as prestressed concrete.

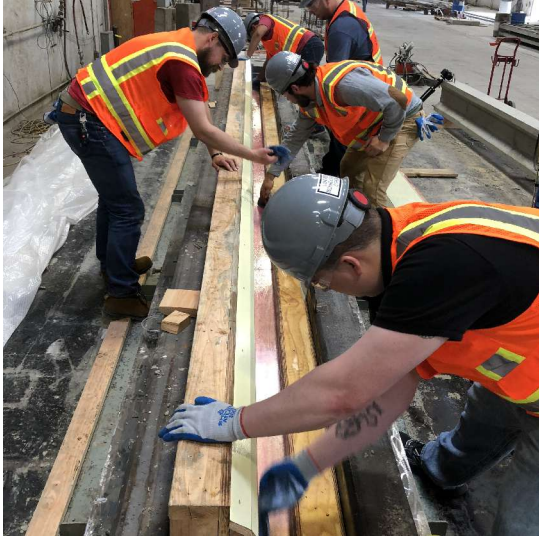
PCI Big Beam Competition

In the PCI Big Beam Competition, student teams work with PCI producer members to design, build, and test a 17-ft-long precast, prestressed concrete beam. The producer member provides materials, construction assistance, and guidance, as well as beam transportation to the testing facility. Saint Martin's University has participated in Big Beam for three years with PCI producer member Concrete Technology Corporation (CTC) as their sponsor.

Saint Martin's University currently offers a prestressed concrete design course every other academic year. This means that some students haven't even had exposure to prestressed concrete before participating in the competition. CTC design engineer Austin Maue travels to the university campus to give the students a "crash course" in prestressed concrete. He arranges plant tours for the students, provides feedback on their designs, schedules construction days with them, and is on site during their beam construction.

Competition participation has been a student-led endeavor, independent of any

St. Martin University's 2017 PCI Big Beam Competition team prior to testing at the University of Washington structural engineering laboratory. Photo: Dr. Jill Walsh.



St. Martin University's 2018 PCI Big Beam Competition team during beam construction. Photo: Jarad Roschi.

course requirements, and accomplishes many of the *Civil Engineering Body of Knowledge* outcomes. Students learn about team work by working together to accomplish competition requirements. They learn about project management by completing design activities to meet construction days that align with the fabricator's schedule. The teams sharpen their technical communication skills by producing a professional report, which includes team predictions and results (see **Tables 3** and **4**). After testing, assumptions for the initial predictions are reexamined and revised predictions are computed. The report includes calculations (math), written discussion on the structural design and the concrete mixture (design), and team member statements on what they have learned (lifelong learning).

Importance of Mentoring

When I was 16, I thought I knew everything. When I graduated with a PhD in structural engineering, I realized just how little I knew. I was fortunate to be hired at T.Y. Lin International and learn from some of the most brilliant bridge engineers in the business. While my education provided a good foundation, it was while working in industry that I truly learned that being a bridge engineer would require a lifelong commitment to continuing education—for both my own advancement and that of the next generation of bridge engineers.

Knowledge transfer is vital in the engineering profession and benefits the mentor as well as the apprentice. Just as mentoring is a knowledge pathway for students and young professionals, it is also a pathway for continued professional development for the practicing engineer. As professionals building knowledge daily, we may too easily forget how far we've come and where we started. Working with students is rewarding. They have fresh perspectives, unburdened by the veteran engineer's "should not" experiences and expectations about cost prohibitions, and they are eager to learn and grateful for the professional's time.

Experience can humble you, change your perspective, broaden your horizons, and open your eyes to new ideas. I hope to present my students with opportunities to learn for themselves about the values of questioning, observing, listening, and pushing oneself to continuously improve and learn. I am proud of the students for their self-directed motivation and revel in seeing how their perspectives are changed by their participation in the PCI Big Beam Competition.

Table 3. Initial Predictions and Test Results

	Prediction	Results	Error Analysis
Ultimate load, kip	34.61	34.88	0.79%
Deflection at ultimate load, in.	6.17	5.44	11.89%
Cracking load, kip	26.37	24.44	7.30%
Total	—	—	19.99%

Table: Jarad Roschi.

Table 4. Post-test Predictions with Hypothesized Corrections and Test Results

	Prediction	Results	Error Analysis
Ultimate load, kip	34.61	34.88	0.79%
Deflection at ultimate load, in.	5.33	5.44	0.06%
Cracking load, kip	24.46	24.44	2.00%
Total	—	—	2.85%

Table: Jarad Roschi.

Acknowledgments

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Reference

1. American Society of Civil Engineers (ASCE). 2018. *Civil Engineering Body of Knowledge: Preparing the Future Civil Engineer*, 3rd ed. (draft dated August 24, 2018). *https://www.asce.org/uploadedFiles/Education_and_Careers/Body_of_Knowledge/Content_Pieces/ce-bok-third-edition-asce-draft-bod.pdf*. Accessed October 15, 2018.