A PROFESSOR'S PERSPECTIVE

DEVELOPING A GREATER FEEL FOR STRUCTURAL ENGINEERING

A faculty approach to augmenting structural engineering students' understanding of prestressed concrete member behavior using parametric analysis

by Dr. John J. Myers, Missouri University of Science and Technology

Just before the holiday season, Dr. Reid Castrodale, the managing technical editor of *ASPIRE*®, approached me with a wonderful opportunity to share my "professor's perspective" on educating our current students and future bridge engineers. This would be a chance to share what I have learned in nearly a decade of practical design experience in industry and, more recently, nearly two decades of experience as a professor and educator at Missouri University of Science and Technology (Missouri S&T), which is one of the oldest civil engineering programs in the nation (2020 will be the 150th anniversary of the start of the civil engineering program and founding of our institution). So, naturally, I immediately said, "Yes!" The next thought that crossed my mind was, "What could I possibly share with the *ASPIRE* audience that would perhaps help other educators in our field influence structural engineering students in their educational development?"

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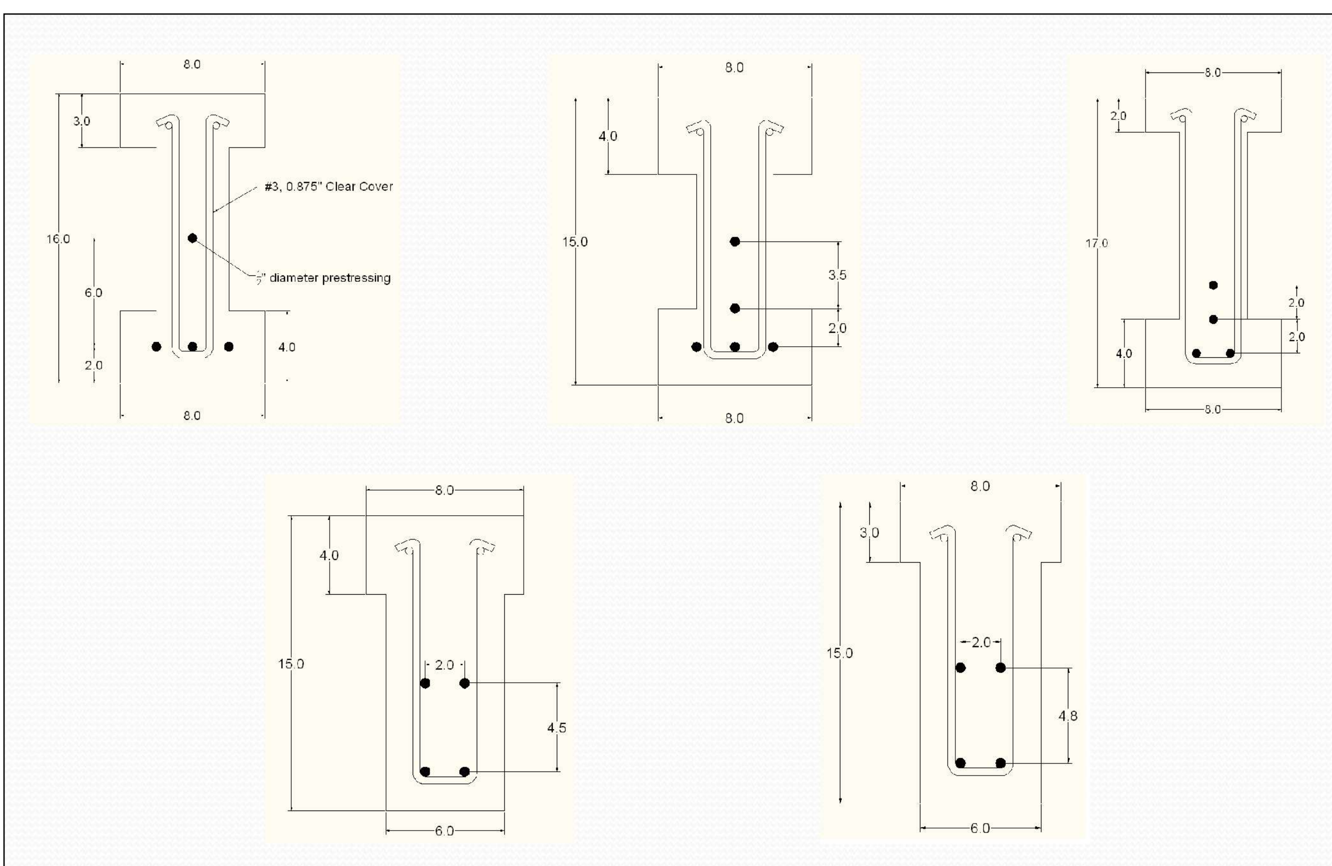
Sample project with cross sections and tendon layouts to be varied to evaluate effects on structural behavior. All Figures: Dr. John J. Myers.



Changing Dynamics in Academia

Before introducing one of my pedagogical approaches to foster an improved understanding of prestressed concrete member behavior, it is important to reflect on the changing dynamics in academia. Nearly two decades ago, when I came to the Rolla, Mo., campus as a young faculty member, one of the first expressions I heard was "the Rolla way." This phrase was shorthand for the long-standing approach we took to educating our engineering students. Being a new faculty member at the time, much like a young college student in his or her first class, I had to question, "What is the Rolla way?" Soon enough, I came to understand that it meant providing not only traditional textbook theory but also a high level of practical and hands-on activities that were integrated within the curriculum experience to produce a more "street-ready" engineer who would be prepared to function at a high level in industry as a design or field engineer.

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Since I joined the faculty, Missouri S&T, like many other institutions of higher learning, has faced both financial constraints and changes in the depth of the engineering curriculum. For example, in my two decades as an educator, state resources directed toward higher learning have dwindled. When I started at Missouri S&T, the state contributed approximately two-thirds of the education costs for a student at our institution; today, the state contribution is about one-third. During this same period, engineering enrollment has almost doubled, which has greatly increased the student-to-faculty ratio. Furthermore, during my tenure, the engineering programs have been streamlined to reduce the required credit hours for a bachelor of science (BS) degree from 141 to 128, both to decrease student time to graduation and to align degree requirements with those of peer institutions.

These changes at my institution reflect national trends. To adjust, Missouri S&T and many comparable institutions have been forced to cut engineering program costs by reducing the number of laboratories and hands-on activities that historically have allowed our students to be more practice-ready upon graduation. Consequently, educators today must be more creative in how we educate our students and take advantage of advances in technology. One bright spot in recent decades has been the emergence of numerous opportunities to provide supplemental experiential and service learning outside of the classroom experience, such as our own Prestressed/Precast Concrete Institute (PCI) Big Beam Competition, the American Society of Civil Engineers Concrete Canoe and Steel Bridge competitions, the American Concrete Institute's student competitions, Engineers Without Borders, and many other activities that engage students in engineering.

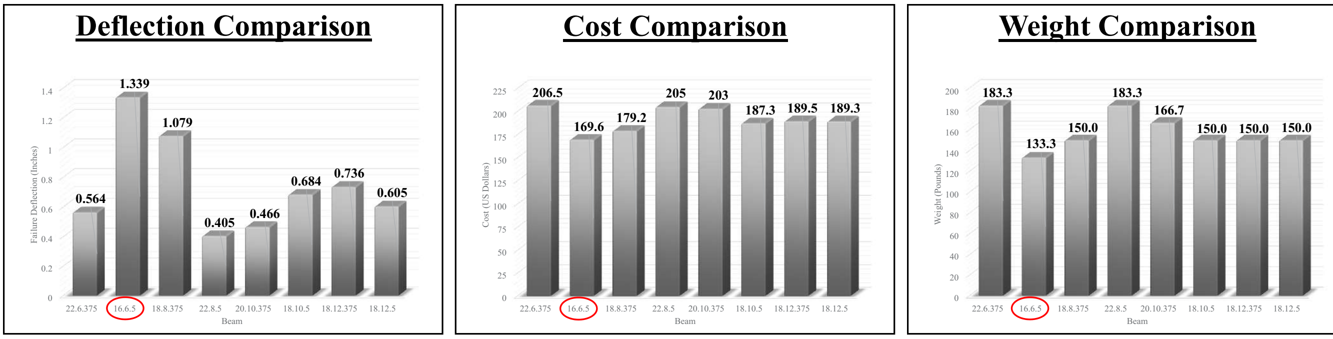
Extending Experiential Learning to the Classroom

Given the budgetary challenges, the reductions in program credit hours, and expanding class sizes, what can educators do to help today's students develop a greater feel for structural engineering member behavior? What are our options when opportunities for physical, hands-on laboratory exercises are limited by the associated costs? Certainly, internships and co-ops can help in this regard. Additionally, activities such as student design competitions and service-learning activities can meet this need to some degree. However, not all students join a design or service team, and even those who participate may not find experiential learning activities that are relevant to their area of study.

Using the PCI Big Beam Competition as a Parametric Learning Tool

In 2003, I began my long-standing engagement as a faculty adviser to the Missouri S&T team participating in the PCI Big Beam Competition (https://www.pci.org/PCI/Education/Student_Education/Student_Competitions/PCI/Education/Student_Competitions.aspx?hkey=6de3c1e2-4fb8-4d16-a4af-bf2032614c2d). For those readers who are unfamiliar with this event, each student team must work with a PCI Producer Member to fabricate a precast/prestressed concrete beam that is tested in a laboratory. Students must design a prestressed concrete component within certain specified requirements and then predict aspects of structural behavior and efficiency, including capacity and serviceability. This event has been the perfect activity for students to apply what they have learned in a typical prestressed concrete design class to a practical application outside of the classroom environment. However, it is not feasible for every engineering student at an institution to compete. Enrollment in prestressed concrete design classes can approach 50 students, which would mean having multiple teams in the Competition, and it would be extremely challenging to solicit sufficient plant sponsorships for that many teams and to pursue member fabrication at the level required in the contest. Also, some prestressed concrete design courses are taught at times that do not coincide with the competition.

Given the limits on the number of students who can compete, my approach, which I am pleased to share with the *ASPIRE* audience, has been to encourage those students who have the greatest interest to participate in the PCI Big Beam Competition and then use the competition's objectives as a framework to offer all students in my prestressed concrete design course the opportunity to undertake a semester-long parametric project. This project helps students improve their practical awareness of prestressed concrete structural behavior by understanding the effect of modifying a design consideration variable and the resulting impact on structural behavior. Through the use of computing capability and software such as Mathcad® or Excel®, students can develop sophisticated spreadsheets to examine everything from allowable fiber stresses to section flexural capacity, shear capacity, and serviceability behavior. With material unit costs, they can examine how changes in structural design affect



Prioritized optimization criteria: comparison of deflection, cost, and weight at failure [measure of section ductility] for various designs.

cost and member efficiency.

In this project, students are first required to develop their parametric matrix by selecting their variables for investigation, which may include member cross section, tendon size, type, and layout; inclusion of mild steel and shear reinforcement; concrete unit weight; and compressive strength. Through their process of study, they must verify which member configurations satisfy all code requirements in terms of transfer and service stresses, strength, and serviceability, and, at this point, they often narrow their extensive matrix to a few members for final consideration. Finally, students examine which sections are most efficient and cost-effective and recommend a final design for fabrication.

Conclusion

The aim of this semester-long endeavor is to combine classroom theory and design aspects studied throughout the semester into a final course project that is geared to help students develop a greater feel for structural behavior through parametric analysis. They develop analysis and design spreadsheets throughout the semester through various assignments and then apply them to the parametric study. This pedagogical approach takes advantage of today's computing capabilities without requiring access to special facilities or laboratories. As a result, the project has improved operational efficiency and offers an alternative approach to traditional hands-on laboratory activities that may have been eliminated in today's engineering curriculums.