Development of Underground Utility Construction Course Curricula for the Granite Heavy Civil Minor

Jared Schlenker
California Polytechnic State University
San Luis Obispo, CA

This paper discusses the introduction of a new course into the Granite Heavy Civil Minor (GHCM) curriculum. This course revolves around underground utility construction and is designed to provide students with knowledge that neither the Construction Management nor Civil Engineering Departments provide. The additional curricula are comprised of underground construction safety, materials, and construction methods that will provide GHCM students with a competitive advantage when applying for jobs in heavy civil construction, further incentivizing the minor program. This senior project utilizes PowerPoint presentations that can either comprise an entire course or be added to existing courses as supplemental information.

Key Words: Granite Heavy Civil Minor (GHCM), Underground Utility Construction, Safety, Materials, Methods

Introduction

Creation of additional curricula to be added to the GHCM is necessary to provide students with a thorough understanding of working around underground utilities. The curricula is intended to comprise an entire course, fulfilling the Technical Elective requirements for both Construction Management and Civil Engineering students enrolled in the GHCM. The motivation behind this senior project is an increased body of knowledge heavy civil contractors are interested in students being exposed to during their time at Cal Poly. The current CM 314 (Heavy Civil Construction Management) course is only able to briefly identify information relevant to underground construction due to the scope of information it must cover in a 10-week period. Underground utility construction may be very hazardous and is unlike other types of construction, which is why curricula provided by this course behoove both students and contractors alike. Multiple internship experiences have proved the shortcomings of a lack of underground utility construction knowledge currently provided to students at Cal Poly. The intent of this new course is to either replace an existing course in the GHCM flowchart or be added to the flowchart in a manner that does not delay graduation. Current course conflicts between Civil Engineering and Construction Management courses have inhibited students from graduating with the minor in four years. This course would be offered as an additional option to GHCM students and is a topic with enough relevant technical data to meet the technical elective requirements for both the Civil and Construction Management departments.

Project Phases

I. Understanding Current Issues With the Minor

The GHCM was introduced to students in Fall of 2019. It gained a lot of initial support from both Construction Management (CM) and Civil Engineering (CE) students, with 50 students enrolling in the program. The minor was intended to give participants an advantage over their peers in heavy civil construction and give them unique networking opportunities with heavy civil general contractors. However, 40% of these 50 students dropped the minor because course conflicts would prevent them from graduating in four years with it. Scheduling minor courses and major courses remains difficult, with many students needing to do course substitutions that are outside of the minor to fill the requirements. While the new material added by the minor is valuable to the student body, students will refuse to enroll in the minor if they realize they will be unable to graduate in four years. If this occurs, donor support will go unrewarded, potentially leaving some donors to be skeptical about funding future programs. The simplest solution to this problem is adding an additional course (or courses) that are relevant to heavy civil construction and do not conflict with current course schedules.

II. Initial Student Interest Surveying

Implementation of a course benefits the student body very little if there is no student interest in the curricula. A survey of the current GHCM body asking the question: “Would a course on managing 811 Tickets, utility marking, and underground utility construction and materials enhance the Heavy Civil Minor?” yielded 94.1% of students responding “yes” (See figure 1.1). When asked if these curricula should be added on top of the current course catalog or instead replace a course, 64.7% of students recommended replacing a course (See figure 1.2). Responses to these two inquisitions posit this course curricula as being useful to the student body (beyond just adding the ability to meet technical elective requirements and graduate in four years). When asked if the current course curricula offered at Cal Poly prepares students for work around underground utilities, 58.8% of students responded “No”. Given there is interest in the course content, and a lack of current knowledge in underground construction amongst the current GHCM body, development of new curricula is a worthwhile undertaking. However, even if most of the student body expressed little interest in learning about underground utility construction in a class setting, it could be of benefit to students to post supplemental information online relevant to underground utilities. In other words, regardless of survey outcome, producing this course curriculum has the potential to benefit the student body. After receiving confirmation of a valid issue with the current GHCM program, as well as receiving interest in the course content from most students, the project moved on to the next phase, production of curriculum.

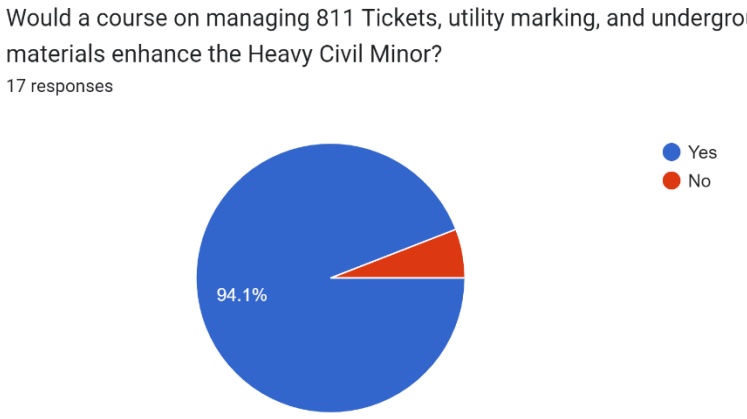

Figure 1.1

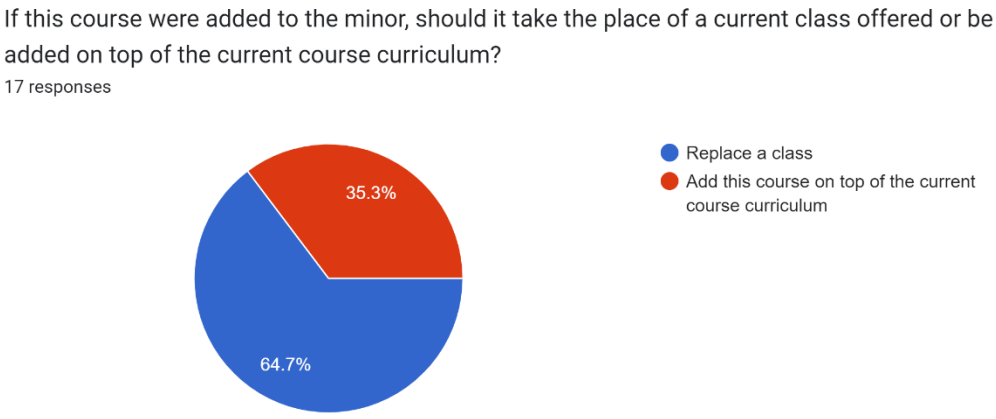

Figure 1.2

III. Production of Curricula

Curricula relevant to underground construction was chosen based upon previous internship experience with Anvil Builders in Morro Bay, California. This project posed a variety of challenges that presented the importance of proper 811 Ticket management, as well as the importance of safety when working around underground utilities. Furthermore, the project entailed the use of a variety of materials that are common in underground construction. The curricula for this senior project covers 811 Ticket management and why these tickets are necessary, general safety practices when working around underground utilities, potholing methods, utility markings, and three common material types - reinforced concrete pipe (RCP), high-density polyethylene (HDPE), and ductile iron pipe (DIP).

These are the materials most often specified in wet utility construction, although there is room for introduction of other materials into the course. The course was developed as a series of Microsoft PowerPoint presentations so course materials can be implemented as a standard course or simply published as an online resource. Material data for the various pipes was taken from manufacturer's websites, with the intent of providing students with necessary technical knowledge to understand the benefits and drawbacks of different materials. Proper installation of these materials is necessary to ensure proper function and longevity of use, which is why installation methods have been implemented as a portion of the course curriculum.

As the project advanced, it became clear that only a small portion of underground construction could be realistically taught in a 10-week class. The project focused on providing a basis for understanding the construction of wet utilities, as well as general awareness of excavation safety and contractor responsibilities. Further scope would be beneficial to students, but it is not likely that this increase would lead to more retained knowledge of underground construction upon students graduating because of the amount of detail that can be involved in a project.

Upon discussion with Ed Boucher (Director of GHCM and Senior Project Advisor) about the scope of the project, it was concluded that focusing on providing basic knowledge would be more beneficial than presenting a broad swathe of information that would be unmanageable. Simply giving students exposure to this material will be a significant learning opportunity, as they will enter their career having a basis to understand underground construction. Copying and pasting numerous pages of technical specifications would yield the same amount of learning as simple online searching.

The first two PowerPoints (introductory slides shown in Figures 2.1 and 2.2) provide basics that a contractor should already be aware of, but a student may not be. These two PowerPoints focus on the steps a contractor must take prior to commencing construction of new underground infrastructure. These steps are important for even a homeowner that will be digging in their own backyard. Mitigating risk and avoiding liability are critical aspects of construction, and striking an underground utility is a mistake that incurs considerable cost.

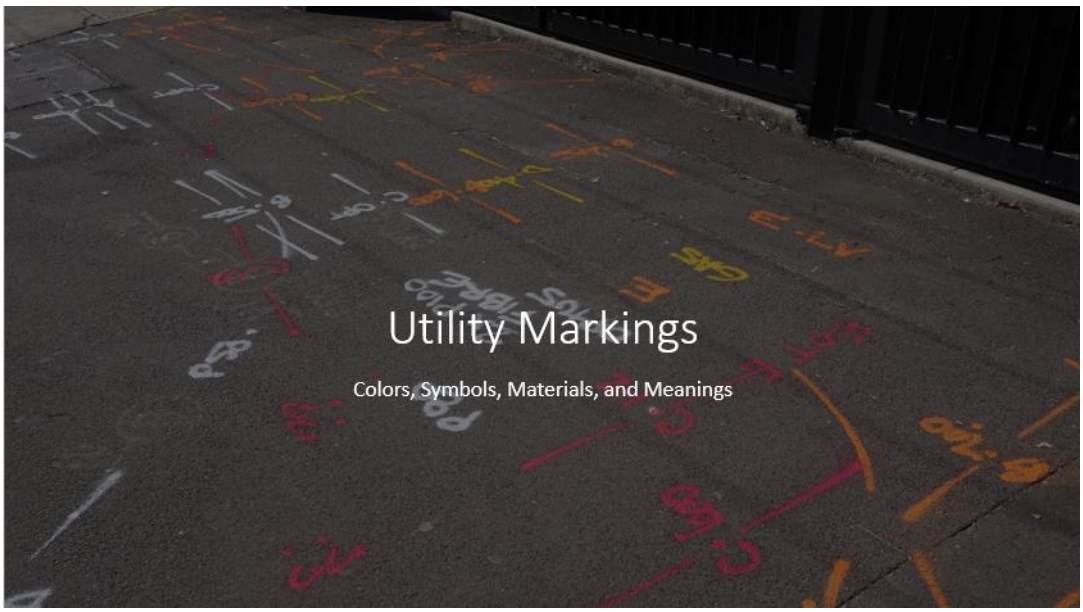

Figure 2.1. Introduction to underground utility markings

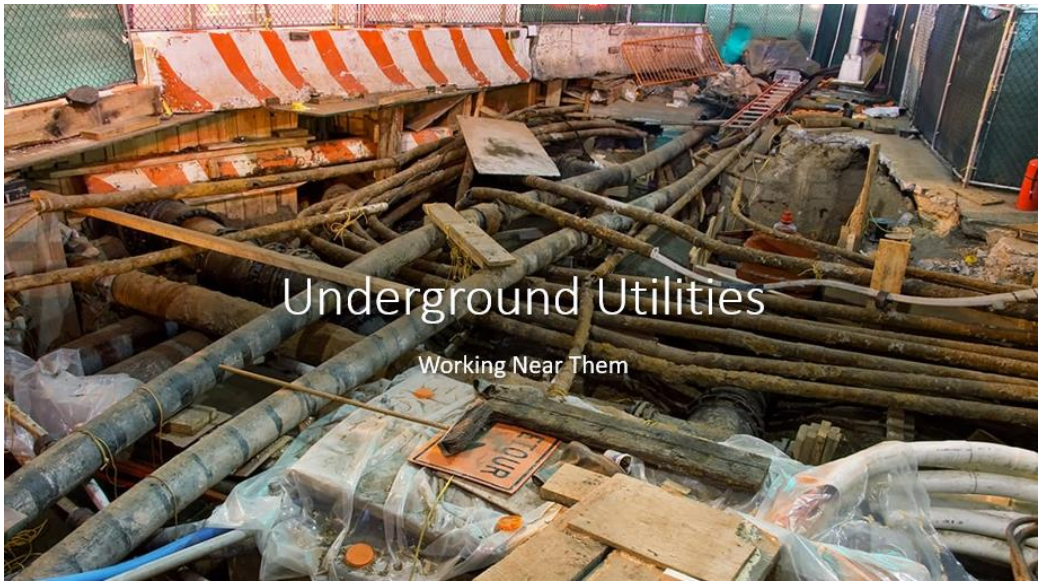

Figure 2.2. Introduction to work around underground utilities

The last three PowerPoints (introductory slides shown in Figure 2.3) focus on the basic properties of materials common in underground construction. They discuss basic methods of assembly and the advantages and disadvantages of various materials (reinforced concrete, HDPE, and DIP), which are the most frequently specified products for wet utility systems.

Figure 2.3. PowerPoints discussing wet utility materials

IV. Project Delivery

This project was delivered in two phases. Phase 1: Interest Surveying; and Phase 2: Curricula Production. A challenge presented by this project is that it did not follow the typical formatting of a research-based senior project. More emphasis was placed on the deliverables than researching a specific topic and consulting field experts, which means the essay formatting had to be revised to accommodate the scope of the project.

Deliverables are available via the Cal Poly Digital Commons, allowing access by students and professors. The survey results from Phase 1 are available for reference and adaptations for any potential future interest surveying. Phase 2 is available in the Digital Commons as a series of PowerPoint slides and an Excel course outline that can be easily accessed and utilized by professors. These slides were kept to a presentable length (about 20 per presentation) to keep students engaged and present a reasonable amount of information during a class period. A total of five PowerPoints were created to work as the foundation for the new course and provide a simple framework through which more course materials could be developed in the future.

Lessons Learned

Developing the framework for this course proved to be a more time-consuming process than was initially thought. Condensing complex information into manageable lectures was often difficult, but rewarding as it provided further knowledge of underground construction for myself. I had a generic understanding of various materials and methods, but this project allowed me to broaden my knowledge on the subject. The further I explored the topic of underground construction, the more I realized was left to learn. For this reason, I would recommend the course be taught by someone with experience in utility construction, as they will have a wide breadth of knowledge that can answer technical questions and simplify complex concepts relevant to underground construction. I have a further appreciation for professors that take the time to develop courses, as I now understand the amount of time associated with creating course content.

Future Opportunities

As mentioned earlier, this course was unable to cover every aspect of underground construction. There is room for further development of materials on wet utilities, as well as other types of underground construction. Cal Poly's future change to a semester system could allow the introduction of a more sophisticated course outline (Figure 3), as students will have more time in each class. Regardless, this course can be broken into multiple courses as the University sees fit. A primary aspect of this project was student surveying designed to gauge interest in the topic of underground construction. Results from this initial survey suggest that implementing an underground construction course could be useful and meaningful for future Cal Poly students. It may behoove the Construction Management Department to follow up with students and address if most Construction Management students would be interested in taking a course of this nature. This material is relevant to not only civil construction, but any construction dealing with excavation or tie-ins to public utilities. Providing students with this knowledge prior to their graduation will make them more valuable to contractors.

Underground Construction Course Outline	
Week	**Topic**
1	**Underground Utility Markings**
	• Introduction to symbology and colors
	• Understanding where delineations for locates must be marked based off plans
	• Practice marking delineations given specific scenarios and plan sets
	• Introduction to 811 North and South ticket management
2	**Excavation Safety**
3	
	• Identifying tolerance zones
	• Identifying appropriate methods of excavation
	• Awareness of blind spots
	• Identification of soil types
	• Understanding dangers of working around utilities
	• JHAs and maintenance checklists
4	**Wet Utilities Materials and Methods of Construction**
5	
	• Pipes (sizes, shapes, and configurations)
	• Advantages and disadvantages of various materials
	• Joining or fusing pipe
	• Methods of installation
	• Hyrdrostatic testing
	• Pipe bedding, backfill, and compaction of trench
6	**Pumps, Lift Stations, and Pump Stations, Reclaimed Water Systems**
7	
	• Analysis of various pump types
	• Lift station purposes and function
	• Pump station purposes and function
	• Water reclamation processes and facilities
8	**Underground Electrical and FO Materials and Methods of Construction**
9	
	• Conduit
	• Duct bank sizing
	• Concrete encasement
	• Pulling fiberoptic
	• Wire gauges
	• Bedding and backfill requirements
10	**Power Generation, Transformers, and Distribution**
	• Nuclear, Hydro, Solar, etc,
11	**Underground Gas Materials and Methods of Construction**
12	
	• Pipe materials and methods of construction
	• Pressure testing pipe
	• Welding pipe
	• Bedding and backfill requirements
13	**As-Built Information for Underground**
	• Documenting layout of alignments
	• Use of tracer wire and warning tape
	• Documenting changes to the contract
14	**Documenting Delays Due to Unmarked Utilities**
	• Extra work orders
15	**Quantity Takeoffs Based on a Given Plan Set**
	• QTO scope to be defined by professor
16	**Quantity Takeoffs Based on a Given Plan Set**
	• QTO scope to be defined by professor

Figure 3. The suggested course outline for a semester calendar underground construction course

Conclusion

This senior project seeks to highlight a gap in the current CM and GHCM curriculum and provide a framework for eliminating this gap. Opinion surveying has provided the consensus that an underground construction course would be beneficial to GHCM students. This course could be provided to all CM students, as the knowledge it entails is relevant across all fields of construction. Future surveying by the CM Department should be conducted to poll the knowledge of important concepts related to underground construction, as well as analyze student interest in this course. This topic has enough technical data that it could fulfill a Technical Elective course requirement, or it could be simply implemented as part of the normal CM or GHCM flowchart. Throughout the project, I learned of the complexities of underground construction that are simply not discussed in course curricula offered at Cal Poly. Addressing these topics would further set the Cal Poly Construction Management Department and Granite Heavy Civil Minor student body apart from the students in similar programs at other universities, meaning they will be desired and hired more by contractors.