

TYING TOGETHER MEANS AND METHODS IN A METHODS OF CONSTRUCTION – CONCRETE AND MASONRY CURRICULUM

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Abstract

Within the construction industry there has always been a demand for skilled management that has an understanding of the concrete processes happening on the jobsite. Managers are expected to be able to answer questions ranging from estimating to constructability within the concrete industry. Without exposure to methods being performed mistakes can and will happen. The goal of Pittsburg State University's School of Construction is to provide these hands on experiences within the management classes offered in the Bachelor of Science in Technology – Major in Construction Management. This paper will focus on the laboratory experiences within the Methods of Construction – Concrete and Masonry course that compliments the management objectives taught within the classroom. There are five focused labs that aim to increase the student's mathematic skills, estimating skills, and constructability skills in the class. The five labs include small building layout and wall form erection, batter board with slab-on-grade placement and rebar installation, tilt-up /precast wall panels erection, equipment operation, and a masonry wall erection. Within these labs students gain an understanding of methods that are required for the completion of a task and then better understand how to complete an estimation of needed material quantities for a project.

Introduction

Using small, hands on, group field based laboratory experiences to further the students understanding of management based production, quantification, and estimating learned in the classroom is one of the goals of the School of Construction.

Methods of Construction – Concrete and Masonry is a 300 level course within the School of Construction at Pittsburg State University (PSU). This course covers a wide range of materials; methods, constructability, equipment, drawings, and specifications, concrete mix design, formwork design, placing and finishing, concrete masonry units (cmu), brick, stone masonry, mortar, masonry design fundamentals, estimation of labor, material, and equipment. The math requirement for this class is to have passed at minimum college algebra. The majority of the students are second semester freshmen and sophomores and have yet to complete an internship or within their respective internship have not experienced concrete and masonry construction. The basis for these labs came from this lack of experience of the students in what could be considered the basics of concrete construction. The completion of these labs also help to meet

the objectives and outcomes used to maintain accreditation through the Accreditation Board for Engineering and Technology (ABET). They are as follows.

PSU School of Construction Educational Objective and Outcomes

- Objective 1: Graduates will have the ability to enter and continue advancement within the construction industry or construction-related industries including managerial or technical positions in construction field supervision, project management, cost estimating, scheduling, contract administration, material testing and inspection, field engineering and surveying, supervised design, technical sales, or governmental regulations.
- Objective 3: Graduates will have technical skills and knowledge in mathematics, science, engineering, and technology to support planning, analyzing, and solving of engineering and construction problems using current and appropriate management and design tools and techniques.
- Outcome 1: Students will demonstrate an appropriate mastery of the knowledge, techniques, skills and modern tools/software of construction related to: contract documents, codes, materials testing, construction layout/surveying, best construction methods/practices, estimating, scheduling, safety, design of construction systems (temporary structures, concrete, foundations, formwork, basic electrical/mechanical systems), appropriate software (Excel, AutoCAD, Primavera, Timberline). [1]

Lab 1: Small building layout and wall form erection

Objective: All participants will obtain a fundamental understanding of the formwork requirements for the placement of concrete including sequencing, methods, safety, materials, equipment and best practices.

This is the lab that started all of the labs that have eventually been added to the class. The first time this lab was completed as an in class activity, it also included the rebar tying portion that is now part of the following lab below. The formwork portion was originally completed with Symons forms that comprised of eight each 2' x 4' sections, and inside and outside corners, and two each 14" x 4' sections. With a class of 28 students they were tripping over one another when trying to complete this lab in the seventy five minute class period. The following semester this in class activity was changed to a two- hour homework lab. The students were broken randomly into groups of two or three and the formwork was updated to include Symons formwork that was 8' in height and enough to build a box that has inside dimensions of 4'-8" by 6'-8".



At the beginning of this lab the students are given the interior dimensions of a wet well that is to be 8' in depth that they need to complete a formwork takeoff using a given set of formwork widths. See figure 1. Directions of how inside and outside corner lengths are calculated, how forms have to match across from one another for ties to be placed and other pertinent information is given. Once they have completed the takeoff of forms needed they are asked to determine a method to layout this structure squarely. The most common answer is extending a 3-4-5 triangle. They are instructed to use the Pythagorean Theorem. This is where students tend to struggle. They know this theory but they are not familiar with the conversion of inches into decimal feet. Math classes typically use metric units or decimal numbers to begin with.

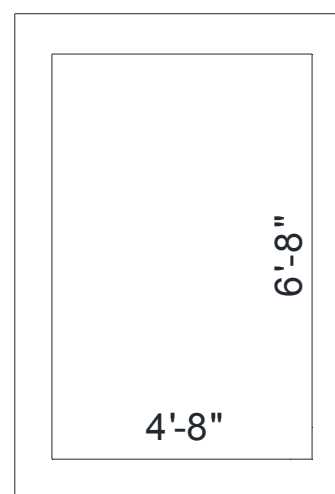


Fig. 1: Plan View Wet Well

The takeoff and layout calculation portion of this class typically takes thirty minutes to complete. Once the students have completed this conversion and calculated the diagonal they will go outside and lay out the interior dimensions using a radial layout method. They then move into the formwork portion of the lab. Depending on the skill of the students all four outer walls can be erected and torn down in the remaining time. While the students are completing these tasks many of the items needed to complete an estimate are pointed out along the way. In the classroom setting the students were not picking up on points such as rubbing and patching, wall ties takeoff, and other items. Once they were able to get their hands on the items and have the purpose of these items explained there was a noticeable increase in scores on tests and homework.

Lab 2: Batter board with slab-on-grade placement and rebar installation

Objective: All participants will obtain a fundamental understanding of the placement of batter boards, various methods of rebar tying, methods of formwork placement on existing slabs or on grade processes including sequencing, methods, safety, materials, equipment and best practices.

This lab was developed to help with the needed requirements for the tilt-up lab. Within this lab the students layout and place edge forms for slabs on grade and for tilt-up panels on existing slabs. The students also place rebar and inserts according to drawings and a manual from Dayton Superior. While working with the rebar portion of the lab the students are shown how to tie figure 8's, saddle ties, and pig tails. Explanations of the positives and negatives for each tying method are given to the students.

The batter board portion of the lab consists of laying out a rectangular slab's corner points and then offsetting each corner with batter boards that are offset five feet from the edge of slab at the corners in both directions. This made eight batter board placements. The students will be given two points to start with and for the finishing of this layout project they use a Sokkia Set 5 Total Station. This is the first exposure to a total station for most. Once they have laid out the points the students set the batter boards to a desired elevation with a Sokkia C300 auto level. Once again this is a first for most of the students. The pictures below showcase some of the items involved in this lab.



Lab 3: Tilt-up /precast wall panel erection lab

Objective: All participants will obtain a fundamental understanding of the tilt-up concrete process including sequencing, methods, safety, materials, equipment and best practices.

The funding for this lab was first completed with a workforce development grant through the State of Kansas. PSU was to offer 24 hours of training to one hundred persons that may have had an interest in construction and could use this on their resumes. Once this training was completed we were able to use the existing plans, equipment, and panels to supplement the labs. This lab is now integrated into the Concrete and Masonry course with two lectures and two labs. The first part of this lab is Lab 2. The second part of this lab is the erection portion where students are divided into groups of approximately 12. This is completed in 3 sessions comprised of a Friday afternoon session and a Saturday morning and afternoon session. Panels are lifted, aligned into position, and braced either by a metal frame or with brace poles. The panels have a combination of openings to simulate what the students could encounter on a project.

“The panels are 5’ wide, 12’ in height and 5” in thickness with an average weight of 3,600 pounds. The metal structure is 11’ in height, 10’ width and 5’ depth with an approximate weight of 400 pounds. Keeping everything light also allows for a smaller crane to be used.

Saturday started with a toolbox safety topic, safety concerns such as pinch points, and starting positions were given and was then followed by bracing panels, placement of panels, and tear down of the panels.” [2]

This is the most expensive lab that is offered in this course. Equipment used were a crane, a 19’ scissor lift, and specialized lifting equipment for the panels. The discounted crane rental price for the weekend cost \$2000, the scissor lift rental is \$150 for the weekend, and the lifting equipment is borrowed from a local contractor.

Nelson Plumb with Crossland Construction Companies helps direct this class. Nelson has 20+ years of experience in precast and tilt-up erection. Nelson also teaches classes for the National Center for Construction Education and Research and transitions easily with the students in this setting.



Lab 4: Equipment operation lab

Objective: All participants are to gain a better understanding of cycle times with various equipment.

The equipment lab has grown over the past three semesters since starting in the spring of 2013. The first semester, equipment utilized was a skid steer, mini-ex, truck and tilt-trailer, power trowel, and a jumping jack. The activities included compaction of a rock base with the jumping jack. Moving the mini excavator into position and scooping a ball off of a cone and swinging the boom into place to dump into a barrel. The power trowel was used on hardened concrete and moved back and forth over a 10' square area. The skid steer was used in conjunction with the truck and tilt-trailer. The students first unloaded the skid steer, maneuvered to pick up a pallet of formwork and placed the formwork in the desired location, with the final step of reloading the skid steer onto the tilt trailer in the reverse direction.

The fall of 2013 semester this lab doubled in scope and included added objectives. The school partnered with Volvo rents to increase the number of activities for the students. Also included this semester were timed activities to simulate cycle time and production. From this students were given assignments that included takeoff of materials that used the cycle times from their activities to complete their estimates. Equipment that was used included an articulated loader, three mini excavators, power buggy, Caterpillar 160 M motor grader, various Caterpillar simulators, two skid steers, and two truck and trailers.



The first production activity included the use of one mini excavator on top of a soil pile and an articulating loader to move the soil. The objective was to move dirt from the north side to the south with the mini excavator. The articulating loader was then used to move the soil around a series of cones back to the north side of the soil pile and the operation was finished once the loader was returned to the starting position.

The second activity used the power buggy and a mini excavator with a sand pile. The operation started by moving the power buggy into position to be loaded by the mini excavator. The operator would load the buggy, drive the buggy around a series of cones dumping the sand back into the pile and finish by returning the buggy back to the original starting position.

The third and final production activity was a skid steer activity. The operator of the skid steer was to fill the bucket of the skid steer with rock, drive around two barrels and through a second set that required the operator to raise the bucket to pass through them. Finally they maneuvered around a third barrel and returned back through the same obstacles before unloading the rock back into the rock pile.

Additional activities included the loading and unloading of a mini excavator and a skid steer off a trailer and reloading them. Included in this activity was the proper placement of chains and chain binders to demonstrate proper transportation requirements to move equipment from site to site. Another activity included the use of a Caterpillar 160 M motor grader. The students were allowed to grade a section of a gravel road and maneuver the blade throughout the range of motions. There were four Caterpillar simulators that included a motor grader, bull dozer, excavator, and a front end loader that the students could operate to gain a feel for the controls before operating all of the equipment out in the field.

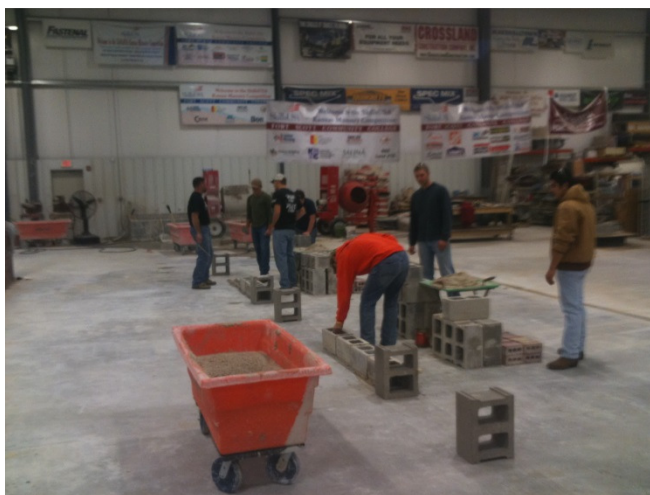


The spring semester of 2014 includes all of the activities from the previous semester along with five additional large pieces of equipment. The five pieces of equipment that have been added are a scissor lift, an aerial lift, a pump truck, a Lull obstacle course, and a crane obstacle course.

Lab 5: Masonry wall erection lab

Objective: All participants will obtain a fundamental understanding of masonry processes including sequencing, methods, safety, materials, equipment and best practices.

This lab has been coordinated in conjunction with the masonry trades program within Fort Scott Community College and Adam Lusker Masonry. The students are first given a demonstration and explanation of the components that are used in a multi-wythe wall systems by Adam Lusker and Nacoma Oehme. They are then turned loose to construct a wythe with concrete masonry units six foot in length by four courses in height. Once this is completed they construct a wythe with brick next to the cmu wall that was previously built. The students are given approximately an hour and half to complete this lab. They usually come away with a great appreciation for a skilled mason.



Lessons learned

1. Smaller grouping is better. With large groups the students cannot develop a report with the faulty member, and time on task is minimal. Smaller groups allow the student and faculty to know one another on a first name basis.
2. Through these lab activities there has been an elevation of understanding of the homework; thus resulting in better scores in these areas.
3. Plan on more equipment stations to keep the queue for the equipment shorter. The equipment lab activities comprised of six stations with activities taking approximately 5-8 minutes each. The lines would become long and the students became impatient.
4. The addition of homework based on student cycle times increased competitiveness of the students. Students wanted to have additional use of the equipment to change their cycle times.

Conclusion

The main difference between these labs and other traditional concrete/masonry lab courses are the groups consist of two or three students with the instructor. The tilt-up lab is the only one in the nation, and typically consists of no more than ten to twelve students with two instructors. This grouping makes it a little larger than a small tilt-up crew. This allows for better one-on-one instructions with the students.

Hands on knowledge is a vital part in a manager's repertoire. When reviewing items with either the site superintendent, site foreman, or the project engineer the construction manager needs to have a working knowledge of all aspects of the construction scope. Hands on learning can help a manager to have the skill set to communicate effectively with all levels of the construction team. This knowledge by students leads to potential savings and advantages in the project. The main difference between this and other traditional concrete/masonry lab courses are that the groups are with 2-3 people with the instructor and for the tilt-up lab this is the only one like this in the nation.

Bibliography

- [1] Pittsburg State University School of Construction, *Educational Objectives and Outcomes*. Retrieved February 23, 2014, from <http://www.pittstate.edu/departments/construction/educational-objectives-and-outcomes.dot>
- [2] O'Brien, Seth E., "Concrete Tilt-Up Construction: Bringing Real World Applications into the College Classroom," *Journal of Management and Engineering Integration*, **5**, (2), 66-70, (2012)