Experiential Preparation for the Classroom

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Abstract

The United States Air Force Academy (USAFA) has provided a comprehensive "hands on" introduction to the civil and environmental engineering curricula. The introductory course known as Civil Engineering Practices-Field Engineering is required of all rising civil and environmental engineering juniors. The three-week laboratory is offered each summer at the Field Engineering Readiness Laboratory (FERL). The philosophy underlying this course is that students benefit from a "hands-on" experience prior to introduction of the technical principles in the classroom. This idea is exemplified by the course motto, "construct first, design later."

The cadets perform a wide variety of engineering tasks during the course. This paper discusses the geotechnical activities performed at FERL and describes how they are integrated into the core classroom work that is required in the soil mechanics course (junior year) the pavements course (senior year) and the geotechnical senior design elective course.

The paper describes the soils walk, compaction testing, and the road building activities that take place during FERL. Examples are presented from both the cadet and instructor viewpoint showing how the FERL experience is linked to the classroom and traditional laboratory. Finally, the assessment process used to determine the effectiveness of the "construct first, design later" integration process is outlined.

Approach

Relevancy is one of the keys to successful instruction. The Air Force Academy believes that relevancy can be created by providing a "hands-on" experience for students who have just declared the civil or environmental engineering major. Their experience begins with a two-week visit to an operational Air Force Civil Engineering Squadron at several bases

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throughout the Pacific Command. Upon their return from the Pacific, the cadets get an intensive three-week course that introduces them to construction activities. Subsequent classroom courses in the junior and senior year can build on the construction experience when introducing elements of design. The motto for this approach is "Construct First, Design Later."

The execution of this approach must be carefully crafted to integrate the construction experience with concepts learned in the classroom. The integration effort takes place on two levels, physical and intellectual. The physical level is grounded in a field laboratory that we call the "Field Engineering Readiness Laboratory" or FERL. The intellectual level is found in homework assignments and class exercises that require the students to recall the construction experience as a setting for the classroom exercises.

This paper describes the integration employed in the geotechnical program at the Air Force Academy. Parallel efforts take place in structures, environmental, and construction practices courses within our curriculum. The cadets are aware that this integration is a vital feature of the engineering experience at the Academy.

Background

The concept of an integrated engineering education has been evolving at the Academy since 1992. Colonel David Swint, the department head, envisioned a curriculum that would be alive with relevancy and produce graduates that would have an unparalleled understanding of engineering concepts and practices. The physical and intellectual components of this curriculum needed a fully equipped field laboratory to support planned student activities that would provide support for later learning of concepts.

Inquiry began into which hands-on activities would translate well into the classroom allowing complete integration between application and theory. Additionally these activities should draw upon the expertise of the non-commissioned officer mentors and faculty. The talents and strengths of each civil engineering subspecialty (structures, environmental, geotechnical and construction) are highlighted in the CE351 curriculum and lend themselves to "hands-on" learning.

During the period 1992-1995, activities included surveying techniques, construction of homes designed by senior students, lab testing of construction materials such as wood, concrete and steel, roadway paving, and construction and design of a concrete beam and steel bridge.

In later years (1996-1999), environmental and geotechnical applications were added to enhance the evolving curriculum. They include water sampling from a local creek, open channel flow demonstrations, a 3-reservoir setup, completion of soil sampling, a Standard Penetration test, compaction testing and a soils walk.

FERL – The Site

The field laboratory was planned in 1992 and ground was broken in 1993. Today the site includes 22 acres and six buildings. The cadets live at the site during the three-week course in a "construction camp" experience.

Civil Engineering 351

The course that provides that construction experience is called Civil Engineering 351 "Civil Engineering Practices - Field Engineering." The course includes 17-training days and is held in June each year. All of the faculty members are involved in the course and the cadets are divided into 5 flights (or groups). The flights are lead by a cadet junior. The flights were formed in May and travel as a group to one of five Air Force Bases overseas to observed both flight and engineering operations at active bases. During the past two years the cadets spent two weeks at a base in the Pacific Command. The flights include Academy cadets and ROTC cadets from selected programs. Seventy-seven cadets from USAFA and 21 ROTC cadets participated last year (June 1999).

Geotechnical Activities

The Geotechnical division instructs three primary courses throughout the academic year. These include a basic soil mechanics course, an advanced soils design course addressing slope stability, bearing capacity and foundations, and a pavement design course. Traditionally, the geotechnical segment of CE351 included a roadway paving activity and a soils walk. This year the activities were expanded to include a drill rig demonstration, field compaction quality control tests and a compaction lesson. Table 1.0 outlines the geotechnical activities conducted during CE351.

GEOTECHNICAL ACTIVITIES AT FERL			
ROADWAY	**SITE INVESTIGATION**	**PLANT VISITS**	**COMPACTION TESTING**
Roadway layout	Hand auger profiling	Portand Cement Plant	Proctor Test
Subgrade compaction	Soil boring	Asphalt Plant	Sand Cone Density
Base course placement	Standard Penetration Testing		
Base course compaction			
Hot Mix Asphalt Placement			
Hot Mix Asphalt compaction			

Table 1.0 - Geotechnical Activities at FERL

Soils Walk

Students were lead on a walk through three different areas of the FERL site. Soil samples were taken with a hand auger and brought back to the soil laboratory for later use. During the outing, students learned soil field classification procedures and gained an understanding of the different soil types, their formation, transportation and engineering properties. Additionally, erosional processes were highlighted that impact the formation of local topography.

Drill Rig

A trailer-mounted drill rig was used to demonstrate soil sampling and testing methods. The students were shown boring with a solid-stemmed auger. They were asked to describe the cuttings. The Standard Penetration Test (SPT) was demonstrated and the cadets counted the blows to advance the spoon and determined the blow count. The cadets were shown the contents of the spoon.

Compaction Testing

This activity readily connected theory and practice. Earlier students placed and compacted base course for the hot mix asphalt placement activity, without any compaction specifications or quality control. Additionally, students had encountered the soil used for this activity at varying moisture contents during the heavy equipment operation phase of the curriculum held the previous week. These experiences were drawn upon to illustrate the importance of the moisture-unit weight relationships via the compaction test.

Discussion focused on the concerns of strength and settlement in using soil as a construction material. Specifically, how imparting mechanical energy and adding or subtracting water would affect the soil behavior. To tie theory to application, standard Proctor tests were completed to establish the maximum dry density of the soil and the optimum moisture content. Students were told how compaction specifications were developed based upon the compaction test results.

Sand-Cone Density Testing

Cadets were placed into groups of three and an upperclassman demonstrated the sand cone density test. Then, each group performed a test on their own. The students were told about the relationship between the compaction testing that establishes compaction specifications and the field density tests that determine that the specifications have been met.

Road-Building Activities

This is the first opportunity the cadets have to utilize their new surveying and equipment operating skills. From a surveying standpoint, the cadets are tasked with laying out the centerline of the roadway and staking the edges to determine appropriate roadway widths and

thickness. Placement, grading and compaction of the base course material is then completed before the asphalt arrives on-site in dump trucks operated by the cadets. Cadets place about 2 tons of asphalt in a day, resulting in about 500 feet of two-lane roadway. These activities are illustrated in Figure 1.0. To add to the reality of the paving operations, cadets are also responsible for traffic control throughout the entire operation

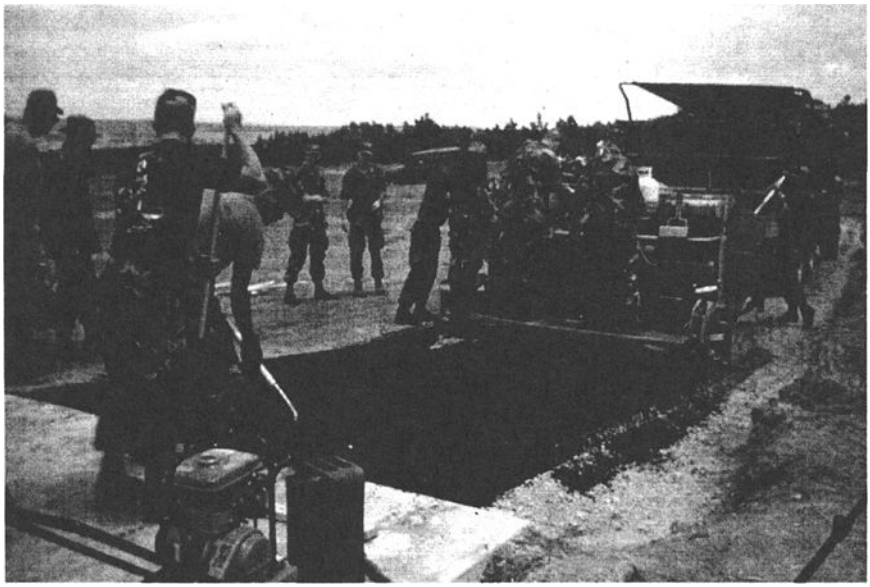

Figure 1.0 - Road building activities at the FERL site

Associated Activities

Each cadet is given the opportunity to operate construction equipment. The students operate a bulldozer, a scraper, and a grader. During the road building activity, selected students operated a dump truck, a front-end loader, and rollers (vibratory smooth-wheeled for earth and smaller steel-wheeled for asphalt finishing). The soil used in the compaction activity was gathered from the soil that had been worked by the students during the scraper operation. This same soil was later used in the classroom activity in the soil mechanics course in the fall semester.

Geotechnical Courses

Civil Engineering 390 Soil Mechanics

The cadets will enter the basic soil mechanics course having just completed the CE351 curriculum and therefore have a basic understanding of the potential uses for soil as a construction material. To kick-off the course, cadets are taken to an area of campus near the academic buildings to complete a soils walk and to collect soil samples. The area they are exposed to in-class exhibits different types of soils and topography, but cadets can draw on their CE351 experience to develop ideas on how the soils may have been formed, how they were transported and how these soils may behave.

Soils collected by the cadets during the soils walk conducted at FERL are incorporated into the laboratory experiments completed in this class. Specifically, the sand material collected was used in the sieve analysis experiment and fine-grained clay materials were used for the Atterburg limits test. The students remember collecting these soils and enjoy the classification process, since they only guessed as to soil type before. The compaction laboratory was also conducted on soils from the FERL site. This tie allows the students to relate the soil to a specific location. It is material that they moved with a scraper, compacted with rollers and collected with the hand auger. It is not soil that just "appeared" in the lab for them to complete their tests.

Civil Engineering 488 Transportation of Pavements

The cadets enter the pavement course having built a section of hot mix asphalt roadway during CE 351. The asphalt road that runs to the FERL site is used as the subject for an exercise in geometric design of a highway. The students have driven that road and have observed its features (grade, width, drainage, and earthwork). The cadets are required to prepare a new geometric design to re-route a section of that road to avoid an environmentally sensitive area.

Civil Engineering 491 Geotechnical Applications

The cadets are taken on field trips during the class periods to the FERL site to observe a drill rig demonstration, examine a set of three retaining wall types, and evaluate earthwork. The FERL site is about 7 minutes driving time from the classroom. The field trips are easily made during a 50-minute period.

Selected cadets had the opportunity to drive an SPT sample and all of the class determined the blow count. The course includes the design of walls. The FERL site has three wall types expressly created for student observation. The site has a soldier-beam and lagging wall, a reinforced concrete cantilever wall and an MSE block wall. The students learn the design principles about retaining structures and they are shown a video that was made of the construction of those walls at FERL.

The cadets are provided with the design drawings for the FERL wall area and they are required to inspect the site and note the "as-built" conditions and contrast those conditions with the features shown on the design drawings. They are also required to make observations concerning the effectiveness of weep holes and site works, such as slopes and surface water drainage features.

Assessment

In order to ensure continuous improvement of the course and to validate the impact CE351 has on United States Air Force (USAF) civil engineering officers, intensive evaluation of the curriculum occurs every summer. These efforts include feedback focus groups, and informal feedback during the follow-on major courses.

The focus group feedback sessions are conducted by personnel from the USAFA Center for Educational Excellence (CEE). The CEE is used for two reasons. First of all, the CEE is staffed with people knowledgeable in the field of course development and evaluation. Course assessment is their area of expertise. And secondly, by utilizing personnel from outside the department to gather the feedback the cadets give more candid and honest responses.

Each of the five flights of approximately 18 students comprises a "focus group". This includes a mixture of USAFA cadets, ROTC students, and maybe a Coast Guard Academy cadet or USMA cadet. The students are asked to list the strengths and weaknesses of the course and then assign a rating to the course from 1 to 5, with 5 as the highest. They are also asked several open-ended questions that were written by the department. The conversations are recorded on audio-tape, but the cadets are identified only be a number. The tapes are transcribed and the results analyzed by the CEE. A sample of the results from the Summer 99 offering of CE 351 are included as Figure 2.0.

The responses to our survey enabled us to assess the success of our integration efforts. The answers we received ranged from very positive, in which the cadets were able to clearly see the importance of the curriculum integration to extremely negative, in which the cadets could draw no significant benefit from the integration attempt. A sample of positive and negative responses is presented in Table 2.0. However, the intent of the FERL experience is best captured in the following survey comment," All was good [Geotechnical activities]. Didn't really know what it was all about until this class [CE390] though. It's valuable after the fact. (looking back)."

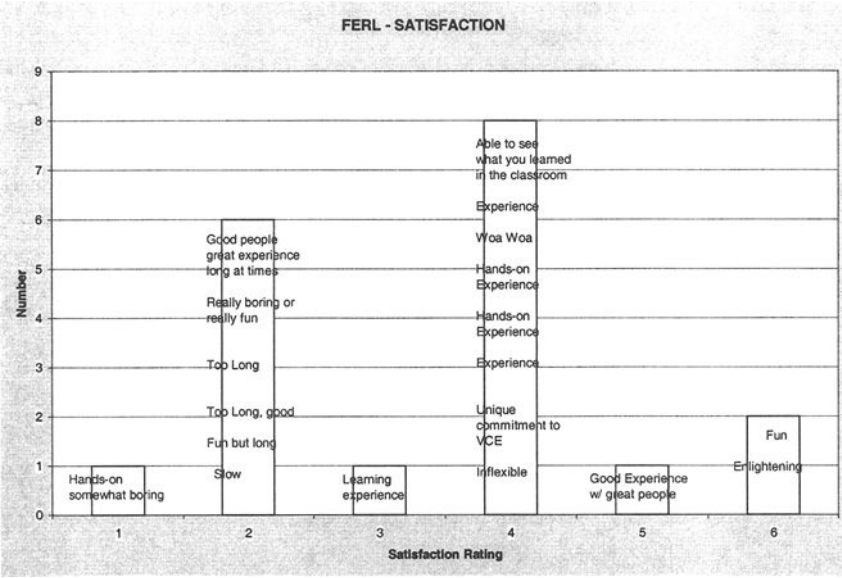

Figure 2.0 - FERL Focus Group Results

Using the sliding scale below, answer the following question.

What is the value in testing in the CE390 Laboratory the soils introduced at FERL?

1	2	3	4	5
Not Important		Somewhat Important		Very Important

Figure 3.0 - Sample assessment questionnaire

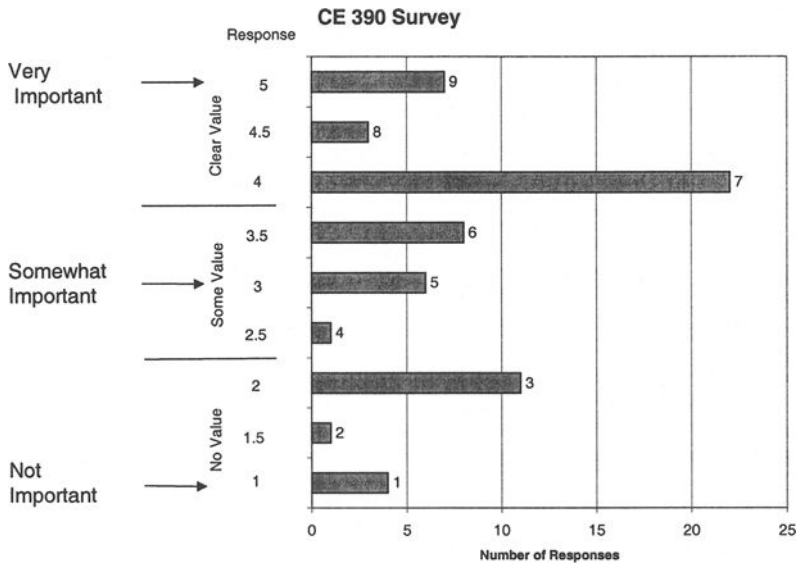

Figure 4.0 - Histogram of CE390 Assessment Survey

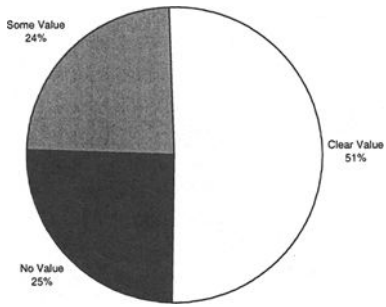

Figure 5 - Results of Soil Assessment Survey

POSITIVE	NEGATIVE
"I think FERL familiarized us with soil types and how to go about testing them. I know I learned that there is a lot more to soils than people think."	"None, because by the time we did the testing in the Lab I had no clue where we got the soil or what the terrain around looked like."
"I can visualize concepts learned in class having seen and touched them before. I can also understand better the importance of soils in construction having put down a road."	[testing the FERL soils was]"not really important, I could have taken the teachers word for it."
"FERL was like a real-world application to what we are learning in CE390."	"I can't say that knowing where the soil came from made much difference."

Table 2.0 - Sample positive and negative assessment survey feedback

Summary/Conclusions

We were encouraged by the results of our informal assessment survey regarding the integration efforts between the CE351 experience and CE390. Three-quarters of the cadets found value in testing the soils first introduced at FERL within the CE390 laboratory, a true testament to the success of the integration. However, the survey also highlighted areas that require some improvement. We plan to address these areas to concentrate on strengthening the link between FERL and the classroom by incorporate photographs from the site and a site map indicating where the soils were gathered. This information will give a visual reminder to the cadets as they begin their laboratory assignments. Additionally, all of the integration efforts have focused on CE390. We would also like to develop stronger field links to the CE491 design course and the CE488 Transportation and Pavements Course. Overall, the results showed that integration is worth the effort.

Acknowledgements

The authors would like to thank the Center for Educational Excellence for the use of their FERL focus group data within the paper. Additionally, we would also like to thank the cadets for their candid responses to our assessment surveys that allowed us to analyze the success of our integration efforts.