Study of Properties of Coastal Pluff Mud at The Citadel

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Abstract

In summer 2019, two undergraduate Civil Engineering majors conducted research with their faculty mentor. The research focused on sampling, testing, and analyzing the index properties of Coastal Pluff Mud. The undergraduate researchers also investigated the effects of adding hydrated lime to the soil. The lime influenced the properties of the soil by increasing its optimum moisture content and decreasing its plasticity index. The collected samples demonstrated important characteristics for future research, such as samples from different locations, even only a few miles apart, behave very differently.

Keywords

Undergraduate Research, Coastal Pluff Mud.

Literature Review

Undergraduate research is considered one of the high impact practices, which are routinely found on college campuses today. The outcomes from undergraduate research range from increasing a student's retention in the major to increased numbers of students attending graduate school[1]. As stated in literature, undergraduates who conduct research show improvements in thinking independently and critically, putting ideas together, solving problems, analyzing data and literature, interpreting research findings, writing and communicating [2-7]. Students involved in research report greater confidence in their ability to work successfully on a team, and listen effectively[2]. These skills, individually and or collectively, could translate into benefits in post-secondary education or professional settings. In addition to the benefits to students, faculty who mentor undergraduate research may benefit by having additional assistance in a laboratory or with data collection, expansion of their own creativity and critical thinking, and overall professional growth[5].

Summer Undergraduate Research at The Citadel

The Citadel's Summer Undergraduate Research Experience (SURE) Program allows students from all disciplines across campus to participate in either a 5-6 week or an 8-10 week research experience based on the preference of the student and faculty pair. Based on the number of weeks that students worked, they are provided a stipend that ranges from $1,000-$2,000. The SURE Program strives to improve student skills integral to performing research. Students and their research mentors are expected to work together for eight hours per week for one-on-one instruction and research skill development. In addition to conducting research with faculty mentors, students are required to attend four lunch meetings throughout the summer experience. These meetings focus on mentoring, professional development, and providing an opportunity for students to discuss research progress with peers. In the first meeting, staff from the campus

Multimedia Services Office conduct a poster preparation workshop in which they teach the basics of designing a research poster. In the second meeting, staff from the Career Center teach effective resume building and interview strategies. The final meetings of the program focus on mentoring in the context of faculty and staff. Perhaps the most beneficial meeting to the mentees allows time for collaboration between mentors from various disciplines.

Pluff Mud Undergraduate Research at The Citadel

The faculty mentor established the Pluff Mud SURE project to be well-defined and aligned with students' abilities. The main planning focus was on all the necessary background knowledge and skills that beginners would need in order to complete the task and these items were taught explicitly to the mentees. Mentor established the learning objectives for the research as shown in Table 1. The faculty mentor also focused on providing constructive feedback, encouragement and balanced criticism with positive reinforcement. In addition, deadlines were set to communicate expectations, weekly meeting occurred to check mentees' progress, and the project's timeline is shown in Table 2.

The faculty mentor involved mentees in all aspects of the research including literature review, planning for data collection, actual data collection, data analysis, and presentation of the findings. Time was also set aside for one-on-one mentoring. At the early stage of research, mentor provided strong support and in later stages of project, mentees were given more independence. Several networking opportunities were provided for undergraduate researchers. Mentees were **e**ncouraged to present their findings at the Southern Conference Undergraduate Research Forum at Wofford in November 2019 and later at the ASEE-SE Conference in March 2020 and to increase interest and improve academic development.

Table 1. List of the learning objective for the research

• Analyze the grain size distribution of the samples
• Analyze the liquid limit, plastic limit, and plasticity index of Pluff mud
• Analyze the compaction characteristics of Pluff mud
• Evaluate the properties of Pluff mud after addition of lime
• Present the research in a conference setting

Table 2. Timeline for research activities

Date	Research Activities
Week 1	• Collect Pluff mud samples and determine moisture content of samples • Weekly meeting to discuss the research progress
Week 2-3	• Sieve/hydrometer analysis, Atterberg limit testing, Proctor compaction test • Weekly meetings to discuss the research progress • Professional development meeting
Week 4	• Analyze data and Read articles on soil stabilizations • Weekly meeting to discuss the research progress
Week 5	• PH testing and applying hydrated lime to Pluff mud • Weekly meeting to discuss the research progress • Professional development meeting
Week 6	• Sieve, Atterberg limit testing, Proctor testing Pluff mud-lime mixture • Weekly meeting to discuss the research progress • Professional development meeting
Week 7	• Analyze data-Results and discussion • Weekly meeting to discuss the research progress • Professional development meeting
Weeks 8-10	• Present the research effectively in a conference setting • Create a poster and present it at The Citadel and Southern Conference Undergraduate Research Forums.

Coastal Pluff Mud

The coastal Pluff Mud is well known for its pungent smell. This local soil is produced from decay of native grasses and marine life. Its rotten egg smell comes from release of hydrogen sulfide by anaerobic bacteria. However, very little is known about the composition of the soil and its potential uses. This makes Pluff Mud a prime opportunity for research so that we may understand its properties, as well as determine if it may be useful in construction and engineering. The objectives of this research are (1) to investigate the index properties of Pluff Mud and (2) to find ways to improve its properties.

Testing Program of Coastal Pluff Mud

The undergraduate researchers investigated two samples of the coastal Pluff Mud, one from a site on campus and the other from a nearby river. Specifically, they determined the basic properties of the two samples such as particle size distributions, Atterberg Limits, optimum moisture content, and maximum dry unit weight (Figure 1). They conducted the following tests on samples of Pluff Mud: Sieve Analysis and Hydrometer test in accordance with ASTM C136[8]; Atterberg Limits tests in accordance with ASTM D4318[9]; Minimum lime content required for soil stabilization in accordance with ASTM D 6276[10]; Compaction test in accordance with ASTM D698[11].

Figure 1. (top left) dry sample of Pluff Mud, (top right) moist sample of Pluff Mud, (bottom left) Undergraduate researcher is performing the standard Proctor test, (bottom right) compacted sample of Pluff Mud.

Testing Results of the Coastal Pluff Mud

The grain size distribution plot (Figure 2) shows that both samples are made up of primarily sand and fines (silt and clay). Figure 2 illustrates that the sample from the nearby river contained 19.5% fines and 80.5% sand. The sample from the campus site contained 5.4% fines and 90.9% sand. The sample from the campus site resulted in a lower clay content than the one from the nearby river. Both samples were classified as silty sand.

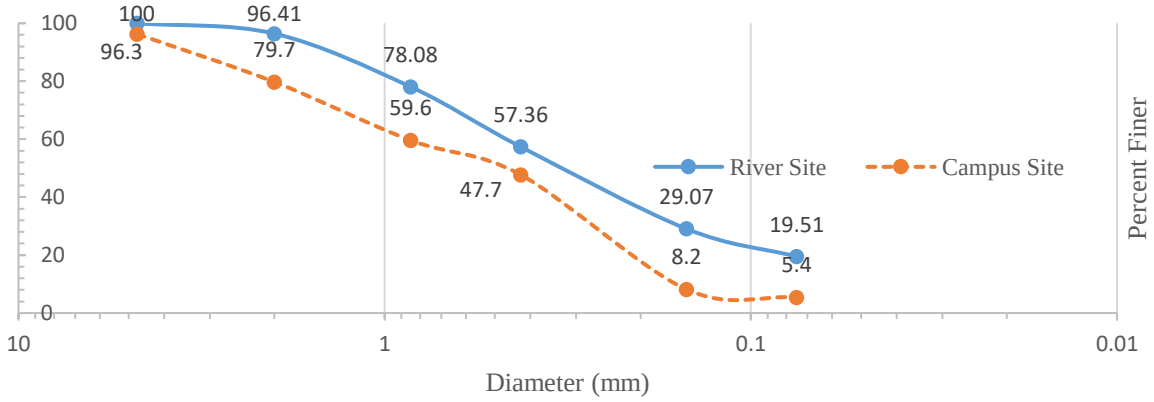

Figure 2. The grain size distribution plot for the two samples.

The workability of soil is related to its plasticity characteristics and is quantified through the liquid and plastic limit and the plasticity index. The plastic limit values were almost identical at both locations; however, the sample from the campus site resulted in higher values of the liquid limit and the plasticity index than the sample from the nearby river. The sample from the campus site resulted in a higher optimum moisture content and maximum dry unit weight than the sample from the nearby river site.

Influence of Lime on Atterberg Limits

Figure 3 shows the Atterberg Limit values before and after addition of lime. It can be observed from this figure that the lime decreased the liquid and the plastic limits and the plasticity index. Upon addition of lime, the liquid limit, the plastic limit, and the plasticity index decreased by 38%, 24%, and 14%, respectively.

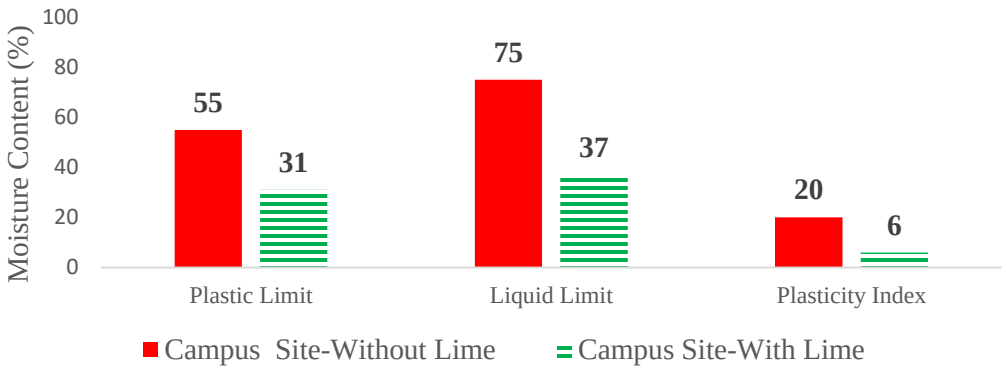

Figure 3. Influence of lime on Atterberg limits

The influence of lime on the optimum moisture content is shown in Figure 4. It can be seen from the figure that the lime increased the optimum moisture content from 23% to 26%. Lime also increased the maximum dry unit weight from 14.5 kN/m^3 to 16.5 kN/m^3.

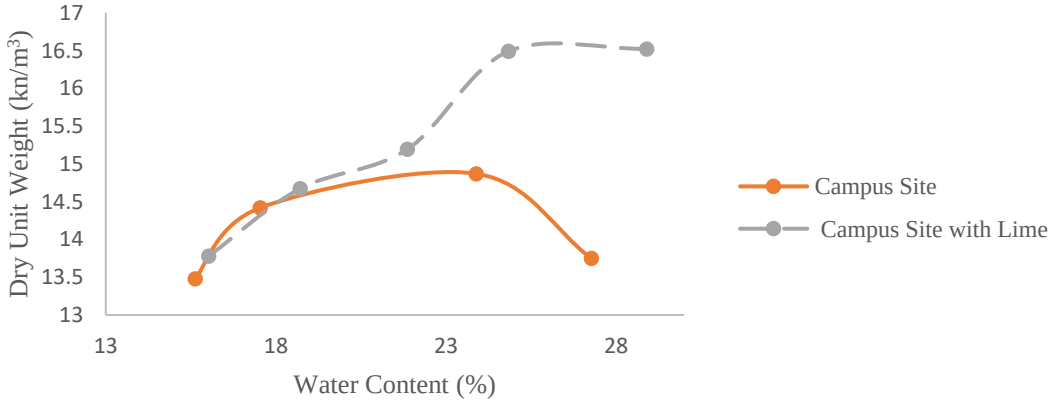

Figure 4. Influence of lime on the Proctor curve

Undergraduate Researcher Takeaways

Undergraduate research has led both mentees to feel a sense of pride and accomplishment in their research. Rather than simply completing tasks because they felt a sense of urgency to get a grade, they completed processes in order to learn something new and different. This created a sense of curiosity, which questioned, "What else can we learn about Pluff Mud?" For the mentees, the research was far different from a typical course - rather than having a professor telling them how and why a given process is used in a discipline, they learned about that process by being involved in it. By conducting the research, it led the mentees to understand how different properties of Pluff Mud can change under different conditions.

The research opportunity also helped the undergraduate researchers learn in a coordinated manner on their own. Typically, mentees would learn new concepts by having the concept introduced to them and would repeatedly study the concept. However, while performing research, they learned about a concept and then applied the concept experimentally. Next, they collected and interpreted the data. Lastly, mentees would attempt to understand what was taking place. In addition to learning information on their own, they also would try to figure out the next step in the process. Working with a peer provided them with new ways to think about and process data critically and creatively. Months after the research was completed, one of the mentees was selected for an internship at an engineering company. The mentee's ability to talk about the materials, procedure, and the research were significant factors in his being offered the internship position.

Conducting research with a faculty mentor has provided great insight into Geotechnical Engineering for undergraduate researchers. Having no prior experience with Geotechnical Engineering, they learned the processes for determining soil index properties. The research has provided researchers with useful skills and knowledge, which have since carried into their Geotechnical Engineering courses, as well as their internships. Lastly, the researchers have also learned valuable information regarding professional engineering, such as ethics, professional conduct, and critical thinking, due to their mentor-mentee relationships with the faculty mentor.

Conclusions

The SURE program helped mentees gain experience in working with others and independently, develop self-confidence, and a sense of ownership of their work. Mentees learned about Pluff Mud through a process of discovery and by being involved in it.

In conclusion, the results of the research found that the plastic properties of soils are affected by the addition of lime. An immediate decrease occurred in the liquid limit of the soil after the addition of lime. The moisture-density characteristics of soils were affected by the addition of lime. Increases in the maximum density and optimum moisture content were observed for Pluff Mud sample. Pluff Mud is a unique soil with its own properties which change with location. While there is still little known about Pluff Mud, what has been observed provides helpful insight into what Pluff Mud is made of, as well as further experiments to be conducted.

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Calvin Pitts is a senior in the Civil and Environmental Engineering program at The Citadel. His fields of interest are Transportation and Traffic Engineering, Drainage Engineering, and Environmental Engineering. Having completed an internship with Mt. Pleasant Municipality in the Transportation Department, he has since received an offer with Cypress Engineering Firm, training for a Civil Design position.

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Marc Dolder is a senior in the Civil and Environmental Engineering program at The Citadel. He has a B.S. degree in Criminal Justice and Applied Mathematics from the University of South Carolina and Charleston Southern University, respectively. His fields of interest are Geotechnical and Environmental Engineering. His research interests are in sustainable and ecologically responsible soil stabilizations.

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