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The Impact of Construction Site Tour During the First Week of Class on Student Learning in an Introductory Geotechnical Engineering Class

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Dr. Oludare Owolabi, a professional engineer in Maryland, joined the Morgan State University faculty in 2010. He is the assistant director of the Center for Advanced Transportation and Infrastructure Engineering Research (CATIER) at Morgan State University and the director of the Civil Engineering Undergraduate Laboratory. He has over eighteen years of experience in practicing, teaching and research in civil engineering. His academic background and professional skills allows him to teach a range of courses across three different departments in the school of engineering. This is a rare and uncommon achievement. Within his short time at Morgan, he has made contributions in teaching both undergraduate and graduate courses. He has been uniquely credited for his inspirational mentoring activities and educating underrepresented minority students. Through his teaching and mentoring at Morgan State University he plays a critical role in educating the next generation of underrepresented minority students, especially African-American civil engineering students. He is also considered to be a paradigm of a modern engineer. He combines practical experience with advanced numerical analysis tools and knowledge of material constitutive relations. This is essential to address the challenges of advanced geotechnical and transportation research and development. He is an expert in advanced modeling and computational mechanics. His major areas of research interest centers on pavement engineering, sustainable infrastructure development, soil mechanics, physical and numerical modeling of soil structures, computational geo-mechanics, constitutive modeling, pavement design, characterization and prediction of behavior of pavement materials, linear and non-linear finite element applications in geotechnical engineering, geo-structural systems analysis, structural mechanics, sustainable infrastructure development, and material model development. He had been actively involved in planning, designing, supervising, and constructing many civil engineering projects, such as roads, storm drain systems, a $70 million water supply scheme which is comprised of treatment works, hydraulic mains, access roads, and auxiliary civil works. He had developed and optimized many highway design schemes and models. For example, his portfolio includes a cost-effective pavement design procedure based on a mechanistic approach, in contrast to popular empirical procedures. In addition, he had been equally engaged in the study of capacity loss and maintenance implications of local and state roads (a World Bank-sponsored project). He was the project manager of the design team that carried out numerical analyses to assess the impact of the new shaft and tunnel stub construction on existing London Underground Limited (LUL) structures as per the proposed alternative 3 design of the Green park Station Step access (SFA) Project in U. K. He was also the project manager of Category III design check for the Tottenham Court Road Tunnel Underground Station upgrade Project in UK.

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Abstract

It has been noted that not all students come to class with a clear idea of significance of the subject matter they are about to learn, it is therefore incumbent on the instructor that the students are assisted to grasps the value and importance of the subject. The quicker this is done, the earlier students will begin investing time and energy into the learning process. The Geotechnical Engineering and Laboratory course is the first introductory class in geotechnical engineering of a civil engineering curriculum and usually many students are not familiar with the principles and concepts of geotechnical engineering. Subsequently, in-order to get students to buy-in into identifying the value and importance of the subject matter at an earlier stage so as to successfully facilitate active learning, it is essential that high impact pedagogical activity be adopted and administered during the first week of class. Subsequently, the active learning strategy adopted by the author in teaching an introductory geotechnical course in a predominantly historical black institution was construction site tour. During the first week of class a construction site tour was organized, whereby the students experienced in real life the application of the principles and concepts of geotechnical engineering in the design and construction of the foundation and structural elements of the infrastructure system under construction. It is pertinent to note that nearly all geotechnical engineering concepts can be exemplified in one way or another by the design and construction of foundation and structural elements of any infrastructural system. The paper describes full details about the construction site visit and the impact on student learning during the semester. The results of the students' report and the survey administered with a portion of about 40 students offering the course (two sessions) show a strong statistical relationship between construction site experience and student learning. The students are engaged throughout the semester in discussion about the linkages between various curricular topics (e.g. soil classification, compaction, ground water, consolidation and shear strength) and the real life application experienced during the construction site tour. The paper further elaborates on how the impact has been felt in comparison to previous semesters when there was no introductory site visit. The results this semester have been dramatically different in students' engagement and learning as students come to class adequately prepared ready to ask questions in-order to satisfy their curiosity from the field trip, working with peers in class and completing frequent assessments of learning. The paper finally recommends that this high impact pedagogy be replicated at other colleges with a civil Engineering program.

1. Introduction

It has been noted that not all students come to class with a clear idea of significance of the subject matter they are about to learn, it is therefore incumbent on the instructor that the students are assisted to grasps the value and importance of the subject. The quicker this is done, the earlier students will begin investing time and energy into the learning process. As on the first day of class, students usually arrive with a great sense of expectation and a range of emotions [1]. What will this course be life? What am I going to learn? Is this going to be boring? Subsequently, as instructors according to McClure (2015)[1], if we want our students to learn effectively we must create conditions that promote intrinsic motivation. Various researchers have studied and tried to identify those factors that contribute to student motivation[1]. While intrinsic and extrinsic rewards and social opportunities play a part, the thing that motivates most learners is the usefulness of the information and its potential for impacting others[2]. According to Hoyt and Lee (2002)[3], research has shown that students' initial motivation to take the course, regardless of who taught it, is an important predictor of student learning. Thus, according to McClure (2015)[1] it behooves teachers in both situations to demonstrate the relevance and significance of the subject matter from the first day of class to the last. Subsequently, teachers can stimulate interest both by showing students the content's real world connections and by involving students in activities that inspire creative applications. The Geotechnical Engineering and Laboratory course is the first introductory class in geotechnical engineering of a civil engineering curriculum and usually many students are not familiar with the principles and concepts of geotechnical engineering. In addition most junior and senior Civil Engineering majors enter an introductory geotechnical engineering course with almost no prior knowledge in geotechnical engineering or geology. Subsequently, in-order to get students to buy-in into identifying the value and importance of the subject matter at an earlier stage and successfully facilitate active learning, it is essential that high impact pedagogical activities be adopted and administered during the first week of class. One of the high impact pedagogy that can be used to simulate interest and appeal to the students' sense of curiosity or adventure at an earlier stage is field experiential learning. Field experiential learning is a part of experiential learning in which learning is done outside the classroom and students are forced to engage with application of concepts in a real world situation. According to Claiborne et al 2015[4], along with the engagement with concepts that is required by these experiences, the student bonding that occurs on the field trips enhances the learning experience and creates a learning community as students continue in a discipline. Teaching in the field also gives instructors the opportunity to get to know their students in greater depth in terms of how students see the world differently than the instructor[4]. This insight into student world-views can help the instructor to better communicate the concepts of the course. According to Mason (1980)[5] field trips at all levels of education contribute well to students learning. His study also demonstrates that there is an evidence that the field trips are as effective as or more than conventional methods. The study finally indicates that field trips are good supplementary teaching methods along other methods. Orion and Hofstein, (1991)[6] also noted that field trips are beneficial to students at all levels because they increase observation and memorizing capabilities and improve recall capabilities ("What you see you remember"). Rebar's (2009)[7] study highlighted that a field trip experience facilitates learner-centered pedagogy. According to Smith (2008)[8] a learner-centered approach helps the students to be proactive.

Solving a geotechnical engineering problem heavily relies on a strong understanding of the basic principles of soil mechanics and a significant amount of judgment. During the first week of class a construction site tour was organized, whereby the students experienced in real life the application of the principles and concepts of geotechnical engineering in the design and construction of the foundation and structural elements of the infrastructure system under construction. It is pertinent to note that nearly all geotechnical engineering concepts can be exemplified in one way or another by the design and construction of foundation and structural elements of any infrastructural system. The paper describes full details about the construction site visit and the impact on student learning during the semester.

2. The Course Geotechnical Engineering and Laboratory

The course is an introductory geotechnical engineering course that is required by all civil engineering undergraduate students. The Geotechnical and Laboratory course has the following catalog description:

Basic physical and mechanical structural characteristics of geotechnical engineering applied to soil classification, permeability and Seepage, In-situ stresses and Compressibility, lateral earth pressures, slope stability and bearing capacity of shallow foundations.

The instructional objectives of this course are:

1. To present the fundamentals concepts, theory, and mechanics of soils for relationships to engineering designs in the environment.
2. To develop an ability to employ broad-based analytical tools for development of soil related concepts
3. To provide opportunities for written and oral communications
4. To provide opportunities for working in teams

While the ABET outcomes addressed by this course are:

1. An ability to apply knowledge of mathematics, science and engineering: (a)-*Reinforcement*
2. An ability to design and conduct experiments as well as to analyze and interpret data: (b)-*Emphasis*
3. An ability to design a civil engineering system to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability and sustainability: (c)-*Reinforcement*
4. An ability to function on multi-disciplinary teams: (d)- *Reinforcement*
5. An ability to identify, formulate, and solve engineering problems: (e)- *Reinforcement*
6. An ability to communicate effectively: (g)- *Reinforcement*
7. A recognition of the need for, and an ability to engage in life-long learning: (i)-*Reinforcement*
8. A knowledge of contemporary engineering issues: (j)- *Reinforcement*
9. An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice: (k)- *Reinforcement*

3. Description of the Teaching Methodology

In conducting the field trip to the construction site the following strategies in line with Claiborne et al (2015)[4] are usually adopted:

Search for any ongoing construction site on campus or very close to campus where students can clearly learn about the applications of principles of geotechnical engineering in the design and construction of the sub-structural/foundation elements of the building as well as learn from the visualizing the structural members of the structures, like beams, columns, foundation, shear walls, roof trusses. The negative factors of field trip as identified by Gunhan (2014)[9], such as time and cost are eliminated because of the selection of the construction site on campus.

A month ahead of the visit a letter is usually sent to the Design and Construction department requesting for permission to visit the site and also requesting for a project manager that will be able to take the students round the site and elucidate the applications of principles of geotechnical engineering in the design and construction of the sub-structural/foundation elements of the building/ as well as critically reveal the structural and foundation members of the building infrastructure. The purposes of the visit is clearly elucidated in the letter and the grading rubrics by which the student field work report will be accessed is even attached with the letter so that the project manager can help in disseminating the appropriate concepts to the students.

Before the site visit the rudiments of the basic hypotheses is given to the student. The various foundation components and the detailed explanation of the foundation design and subsoil investigation of the infrastructure is given similar to the ones they will see in the field are given to the students. Also the design and construction of foundation of different infrastructure ranging from earth dams, power plant, tunnels, high rise buildings and embankments are presented. Students are also provided with the report of the geotechnical investigation of the site, architectural and structural drawings of the infrastructure before the visit.

Students are instructed to wear appropriate attire during the visit: thick sole shoes (boots with treads), pants, shirts with sleeves. No tennis shoes, open toe shoes or heels.

Students are briefed on safety issues before entering the construction site and they are provided with reflective vest, googles and hard hats as safety measures. Figure 1 shows the students in their safety measures attire.

The project manager then accompanies the students to the site office, where he describes the entire building project and briefs the student about the architectural and structural components of the building. The briefing usually takes about an hour and the instructor interjects intermittently to ensure that the necessary concepts are passed across to the students.

Figure 1: Students in their safety measure attire during the construction tour

After the briefing the students are then taken round the site where they are shown how the concepts they will be learning in class are applied to the design and construction of the foundation and structural elements of the building like: beams, column, shear walls, retaining walls, roof trusses etc. In addition during the tour the students are able to witness the application of principles of geotechnical engineering in the design and construction of the sub-structural/foundation elements of the building/ as well as critically reveal the structural and foundation members of the building infrastructure. The students are also briefed about the various problems encountered during the construction, how the problems are solved and the lessons learnt. At the end of the construction site tour the students are asked to produce a video of the site tour and write a detailed site visit which must be in alignment with the supplied rubrics.

The students are assessed on how they can be able to succinctly describe the site, the foundation and substructure and superstructure of the infrastructure. They are also evaluated on their ability to relate the application of principles of geotechnical engineering in the design and construction of the sub-structural/foundation elements of the building/ as well as critically reveal the structural and foundation members of the building infrastructure. Finally their organization and logical presentations of ideas are assessed. The concepts and principles of the application of geotechnical engineering in the design and construction of the foundation and structural elements observed in the construction site are used as a curricular arc throughout the semester. The students are engaged throughout the semester in discussions about the linkages between various curricular topics and foundation design and construction (e.g soil classification, compacting, groundwater, consolidation, shear strength). Nearly all geotechnical engineering concepts can be exemplified in one way or another by the subsurface investigation and foundation design (Ghanat et al 2016)[10]. Lesson leant from the construction site visit are also used to explain and reinforce conceptual idea, as many students tend to retain what they see visually. Students are also required to participate on a discussion on titled: “What are the consequences of wrong estimation of structural loadings?”

4. The impact

The instruments that are used to assess the impact of the real-life application pedagogy on student engagement were the students’ field report and a survey that was conducted with participating students. The survey questions are similar to the ones adopted by Lobbesteal and Sleep (2016)[11] to access the impact of the new Geotechnical Engineering problem based learning modules (Hurricane Katrina module) on students’ perception of Geotechnical Engineering.

Subsequently, in order to demonstrate that the real life application of concepts of geotechnical engineering experienced on the construction site, actually facilitated the acquisition and integration of geotechnical engineering knowledge, the essential components of two students field report are shown in Appendix A.

The students’ reports A & B in Appendix A demonstrate a mastery of the concepts of geotechnical engineering in the design and construction of the building as well as the appreciation of the importance of geotechnical engineering by the students.

Student A demonstrates a mastery of the concept of geotechnical engineering, and an in-depth understanding of the structural and foundation members of the buildings. Through Student B report in Appendix A, it is clearly seen that the student thoroughly understands the concept of foundation design, and the student comprehensively reported the application of the principles of geotechnical engineering in the design and construction of the foundation of the building.

Additionally, in-order to measure the effectiveness of the construction site visit on attitude and initial motivation in the course as well as the appreciation of the importance of geotechnical engineering, the students were asked to evaluate their learning experience with the site visit. The students were asked to rate the evaluation statements on 1-5 scale range (Table 1), with 1 indicating strong disagreement and 5 designating strong agreement in-order to measure the effectiveness of the field trip experience. No incentives were given to students when evaluating the field trip and the students were not requested to provide their identification.

The findings indicate that students favored the learning experience. Respondents agreed that the field trip during the first week of class has greatly facilitated their comprehension of the technical content of the course (Statement 5), even though the majority of the students did not have prio knowledge in geotechnical engineering or geology before the site visit (Statement 7). The results equally suggest that students generally felt that the construction site visit increased their appreciation of the importance of geotechnical engineering (Statements 2, 3, and 4). Overall students also generally agreed that the site visit increased the technical value of their work (Statements 1, 5 and 6).

The students are engaged throughout the semester in discussion about the linkages between various curricular topics (e.g. soil classification, compaction, ground water, consolidation and shear strength) and the real life application experienced during the construction site tour.

Table 1 Evaluation Results of the Construction Site Visit

Statement Nos.	Evaluation Statements	Mean Rating (N-23) Scale (1-5)	Standard Deviation
1	Visiting a Construction Site in geotechnical engineering has led me to explore/investigate items beyond the scope of the problem.	4.39	0.8387
2	Visiting the Construction site and witnessing real applications of geotechnical engineering has led me to appreciate the Contribution of geotechnical engineering to the broader discipline of civil engineering.	4.826	0.49102
3	Observing the potential consequence of failure in geotechnical engineering problems has increased my appreciation of the societal value and importance of geotechnical Engineering.	4.304	1.2223
4	Observing the potential consequences of failure in geotechnical engineering problems has led me to consider the ethical implications of geotechnical engineering assumptions and decisions.	4.347	0.8847
5	Visiting the Construction Site during the first week of class has helped me to better comprehend the technical content of the course material.	4.0	1.3484
6	Solving problems in geotechnical engineering has allowed me to exercise my engineering judgement.	4.26	1.05388
7	Please rate your knowledge of geotechnical engineering before the site visit 1 been very low and 5 being very high	2.087	1.12464

From the instructor's observation, the results this semester have been dramatically different from previous semesters where there was no site visit during the first week of class in students' engagement and learning, as students come to class adequately prepared ready to ask questions in-order to satisfy their curiosity from the field trip, working with peers in class and completing frequent assessments of learning.

Students' attention levels and interest also seemed to be relatively higher this semester. Subsequently, the uniqueness of this pedagogy is the introduction in the first week of class and it can been seen that the benefit has been immense. Students also agreed that their understanding of the course content has drastically improved. They felt more confidence because they can relate what they learn with the real world situation. One of the students mentioned "Before we started this class I was not exited for it. I even did not know what it is about. I thought Geotechnical Engineering course is similar or another level of Geospatial Technology course. However, when the semester started we went to the construction site. From that visit the whole idea about Geotechnical Engineering changed. It was very interesting in my opinion. Also, meeting experienced engineers changed all my thoughts about Civil Engineering. They are very precise and careful in everything. I am being very honest and in my opinion, the site visit was very useful and changed a lot in my mind". The site visit really helped to connect theory with practice as another student commented: "This site visit was a good approach for us, students taking the class for the first time. It helped us learn more of what we are going to do exactly, not only we do problems but also how to apply them with real life situations. This site visit even made me love what I am doing, I am learning information from class notes and go on the field, to examine them, obtain more information and be more with construction workers and engineers". Another student also commented: "The visit has impacted me in learning and engagement in this class. I learned many things in the site visit especially about best site location and why geotechnical engineering is important". The site visit has also been successful in enhancing the cognitive ability of the students as well as increasing students' interest and attitude towards geotechnical engineering. Another student noted that: "The site visit was useful because it helped me see some of the difficulties concerning soil quality that engineers face. It was also helpful to see some of the implications to the design of foundations and even the structure above grade". Another student equally commented: "In engineering, practical experience is highly valued. When constructing a new building, it helps to know the problem that might arise when placing a new structure on a foundation. The site tour that the Geotechnical Engineering class took to the construction site of the new Morgan State University Campus building was useful in gaining knowledge that will help me in the engineering field. During the site tour, I got to see how the structure is built to interact with the surrounding soil and the order in which the building has to be constructed. Another student also stressed the efficacy of the site visit by commenting that "The site tour helped me to investigate many things in real site far away from the class. Since I like to learn how the work going in real site, better than learning in class, it gave more knowledge about what I will face in this course. I observed the potential consequence of failure in geotechnical Engineering problems and how much important to understand the foundation". Another student also said that "The site visit has given insight on the geotechnical aspects that goes in the design process of construction. The hands-on experience gave me the knowledge visually. This will allow myself to identify while on my own."

The observations by the instructor of the students' performance and attitude towards Geotechnical following the construction site visit has been very encouraging, this has really motivated the instruction to do more of the construction site visit.

5. Conclusion.

Students' initial motivation to take any course, regardless of who taught it, is an important predictor of student learning. Subsequently, it behooves instructors to demonstrate the relevance and significance of the subject matter from the first day of class to the last. Instructors can stimulate interest both showing students the content's real world connections and by involving students in activities that inspire creative applications. One of the most effective pedagogy that can be used to early increase students' motivation and attitude towards a course is field experiential learning. It has been demonstrated in this paper that the field experiential learning pedagogy adopted via a construction site visit during the first week of an introductory geotechnical engineering course was successful in enhancing the cognitive ability of the students as well as increasing students' interest and attitude towards geotechnical engineering. Typical field trip constraints as observed by Gunhan (2014)[9] such as logistics, time and cost limitations were eliminated.

The results of the students' report and the survey administered with a portion of about 40 students offering the course (two sessions) show a strong statistical relationship between construction site experience and student motivation and learning. The students are engaged throughout the semester in discussion about the linkages between various curricular topics (e.g soil classification, compaction, ground water, consolidation and shear strength) and the real life application experienced during the construction site tour. The paper further elaborates on how the impact has been felt in comparison to previous semesters when there was no introductory site visit. The results this semester have been dramatically different in students' engagement and learning as students come to class adequately prepared ready to ask questions in-order to satisfy their curiosity from the field trip, working with peers in class and completing frequent assessments of learning. It is highly recommended that this high impact pedagogy be replicated at other colleges with a civil Engineering program, however, sufficient planning has to be made in-order to eliminate typical field-trip constraints.

References

1. McClure, N. (2015). "Demonstrating the Importance and Significance of the Subject Matter". *IDEA paper No. 41*
2. Bransford, J. D., Brown, A. L., & Cocking, R. R. (1999). *How people learn: Brain, mind, experience, and school*. Committee on Developments in the Science of Learning, National Research Council. Retrieved May 19, 2005 at http://stills.nap.edu/html/howpeople1/

3. Hoyt, D.P., & Lee, E. (2002). Technical report no. 12: Basic data for the revised IDEA system. Manhattan, KS: The IDEA Center. Retrieved December 6, 2011

4. Claiborne, L., Morrell, J., Bandy, J., and Bruff, D. (2015). "Teaching Outside the Classroom". https://cft.vanderbilt.edu/guides-sub-pages/teaching-outside-the-classroom/ (Accessed on 03/2016).

5. Mason, J. L. (1980). "Annotated Bibliography of Field Trips Research". *School Sc. Math., 80(2), pp. 155-166*

6. Orion, N. and Hofstein, A. (1991). "The Measurement of Students Attitudes Towards Scientific Field trips". Sci. Educ., 75(5), pp 513-523.

7. Rebar, B. M. (2009). "Evidence, explainations, and recommendations for teachers' field trip strategies". Doctoral disseratation, Oregon State University, Corvallis, OR.

8. Smith, G. A. (2008). "First-Day Questions for the Leraner-Centered Classroom ". *The National Teaching and Learning Forum, Vol. 17, Nos. 5,.*

9. Gunhan, S. (2014). "Collaborative Learning Experience in a Construction Project Site Trip. *Journal of Professional Issues in Engineering Education and practice, Vol. 141, Nos. 1 pp. 1-5.*

10. Ghanat, S. T., Kaklamanos, J. K., Ziotopoulou, K. Z., Selvaraj, S. I, and Fallon, D. J. (2016). "A Multi-Institutional Study of Pre-and Post-Course Knowledge Surveys in Undegraduate Goetechnical Engineering Courses". *ASEE Annual Conference and Exposition, New Orleans, LA, 2016.*

11. Lobbesteal, A. J., and Sleep, M. (2016). "Investigating the Effectivenness of New Geotechnical Engineering Problem-Based Learning Modulus for Student Comprehension and Attitude at Two Universities." *ASEE Annual Conference and Exposition, New Orleans, LA, 2016.*

APPENDIX A
Esential Components of Students A and B Reports

Student A

"Description of Site Foundation, Substructure & Superstructure of the Building

The gross square feet of this new building is proposed to be approximately 137,000 and it is to sit about 5 stories high. A number of field tests were conducted on the soil at the site location which revealed the various soil types present and their characteristics. This information enabled the personnel adapt to their working plan. Due to the nature and height of the building, it was important that the foundation of the structure sit on the bedrock. In this case, this meant the foundation had to be approximately 25ft deep.

Some noteworthy problems were encountered while preparing the soil for construction. Remains of broken rocks, disintegrated foundation remains of previous demolished structures at the site as well as groundwater levels posed great danger to some of the facilities and utilities of the structure and particular attention was made in preparing the foundation to those areas of the land site. Also, the biological and chemical process of weathering of rocks in the Baltimore area made it necessary to perform extensive field tests to explore the nature of the land further before any construction.

Tests were conducted both in the lab and on the field to determine the moisture content, compaction of the soils present, and fill soils present. The substructure of the area or the bedrock is the Baltimore Gneiss. The foundation essentially was placed on undisturbed soil and compacted soil working in amalgamation to withstand abnormal pressure levels. The slope and elevation of the land was also observed and the calculations incorporated into the overall design of the building.

The new Behavioral and Social Sciences building also boasts of drainage systems in the substructure to monitor groundwater levels and prevent it from causing damage to the structure. The drainage system prevents the ground water level from ever getting remotely close to floor slab or damaging the walls.

Application of the Principles of Soil Mechanics & Geotechnical Engineering

Geotechnical engineering is largely defined by all systems and structures that are in one way or the other supported by rock/soil. It is a very broad aspect of civil engineering which deals with the preparation and construction of foundations, landfills, slopes etc. in anticipation of building a structure. Some of the sub concentrations of geotechnical engineering include soil mechanics, rock mechanics, subsurface structure, hydrogeology, and geo-environmental engineering. The Behavioral & Social Sciences building like any other building had to have geotechnical engineers present for an analysis before any work could be done.

Soil Mechanics helps engineers to determine the characteristics of the soil under duress in terms air, water, and mineral content. The soil present at the site in question had trace amounts of Silts, Lean Clay, Silt Sand, Poorly Graded Sand, Clayey Gravel, and Clayey Sand. The soils present at any particular site are very important because foundation that sits on soil with bad structure can cause the foundation to crack or the building to collapse. Clay chemically has a better structure and thus, has a higher strength. Ultimately a good mix of the different soils is ideal for building purposes. Each soil contributes its own unique trait in the overall strength from water holding capacity to compatibility. It is imperative to examine the water holding capacity of the soil present at the site because the soil needs to be able to "hold" excess water during the wet season without damaging the foundation. A good engineering technique will be to construct and install drainage pipes that may direct water away from the site in order to prevent damages.

Other tests were conducted to determine the favorability of the soil present. Among these was a standard penetration test. The penetrations test makes use of a sample of soil from the location that has not been disturbed and it is checked for its density and moisture characteristics. This test is cost effective in determining the density of a soil sample. A tube is used to penetrate the soil at equal distance as regulated by the guidelines of ASTM D1586 (American Society of Testing & Materials). The number of "blows" it takes for subsequent penetration levels is what is referred to as the N value or the blow number. The count for the number of blows gives an approximation of how dense the ground is although there are some theoretical formulae that can be manipulated to achieve that value. The soil at the site had a blow count of 2 to 30 blows for every foot of soil.

The soil surface also required some milling (crushing and grinding of aggregate/rock remains) in order to level the site for other activities. The milling of the surface at Northwood plaza prepares the land for asphalt in anticipation of a parking lot for both students and faculty. The nature of the land present was not level and that called for elevation of certain regions of the land by scale factors in order to create some proportionality. The nature of the site also called for up to about 8 feet of structural fill for optimum results in construction of the 5 story building.

Another noteworthy aspect of the construction was the use of aggregate piers. Aggregate piers improve the cohesion of the soil. It is typically cost effective an ideal way of increasing the bearing pressure of soil sample and also reinforcing some soils that maybe considered "soft". The aggregates were formed by initially drilling a hole and introducing stones (AASHTO No. 57) into that opening. It was then compacted at very high energies using special equipment. The site also featured a significant amount of groundwater which had to be incorporated in the construction of the floor slab. To adequately and efficiently protect the floor slab, sub drainage systems had to be put in place. A blanket had to be introduced into the design of the drainage system so as to prevent non filter material. The drainage system relies on both gravity (due to elevation of the land) and a mechanical pump at vantage points. Geotextile fabrics were used in conjunction with the pipes and systems to help the drainage filter materials in the separating filter and non-filter materials (permeability).

The application of the theories and concepts involved in geotechnical engineering enables one to determine the nature of the land and therefore how to design and construct accordingly. Since a significant portion of the load that a building carries is felt in the soil through the foundation, proper geotechnical due diligence is of paramount importance. Important work like underground parking, pipes and drainage systems are developed using the constructs of soil mechanics. Analysis of soil and rock characteristics is also important in anticipating potential problems a structure may face and thus relaying information to other engineers to include in their design. Thus making, geotechnical engineering a backbone to all construction related fields.

Student B:

Site Description and Photographs

Our tour began with a brief introduction of the building by Architect, Ms. Wilson. She explained, the building started construction in 2015 and is nearly complete. The building is a 5-story concrete structure with post tensioned slabs for floors 2 through 5. The foundation is built on grade supported by drilled concrete piers called caissons. The exterior walls are self-supporting curtain walls (Fig. A1).

Figure A1. Picture of exterior curtail wall.

The curtailed wall does not support the weight of the floor system, but instead supports the windows, finishes and loads associated with its own weight.

The foundation water proofing system can be seen here (Fig. A2). A thick layer of water proofing prevents any water seepage into and up through the foundation slab. While water proofing wrapped from foundation to the underside of the exterior curtain walls (Fig. A3).

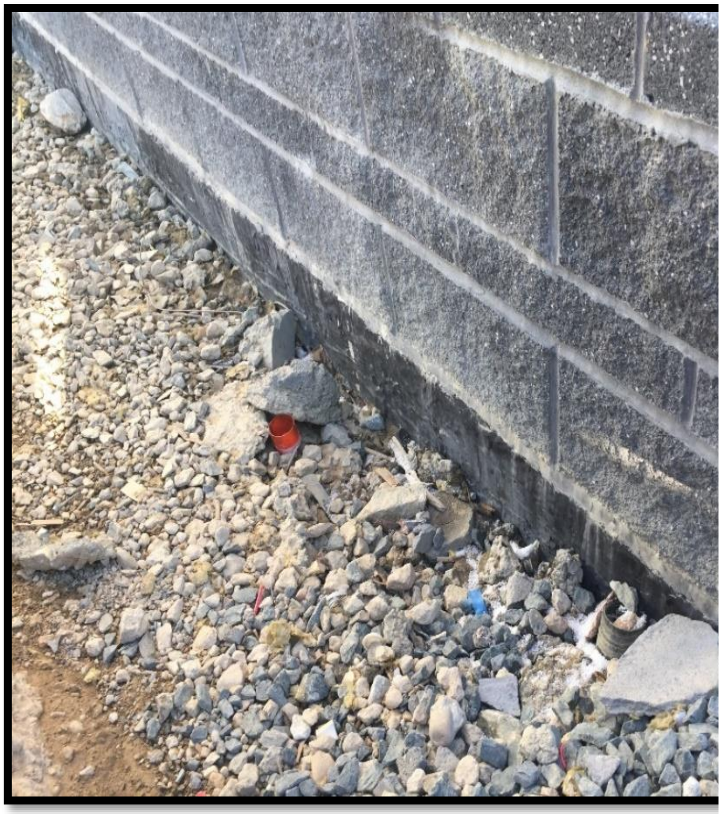


Figure A2: Water Proofing System

Figure A3: the underside of the exterior curtain walls

The site is far along in construction thus much of the substructure and foundation could not be physically seen on our tour. However, Ms. Wilson did point out some important aspects regarding the soil and foundations required for the building. Ms. Wilson described the difficulties with the soil on this urban site. The difficulties with the soil stem from the existing building that was demolished to build this project. The demolition and previous construction left a lot of debris, buried boulders, and loose soils. She noted that there were instances where these boulders had to be removed and fill soils brought in to fill the holes. In the next section, I will go into further detail with the geotechnical report. Ms. Wilson also noted, they installed an under-slab water collection system with a sump pump at the lowest point to expel any excess water away from the building.

Figure A4 shows an overview of the first floor foundation plan as given b Cagley and Associates p.S101. Note the circular locations of the drilled piers (Caissons) that bear the structural load of the building.

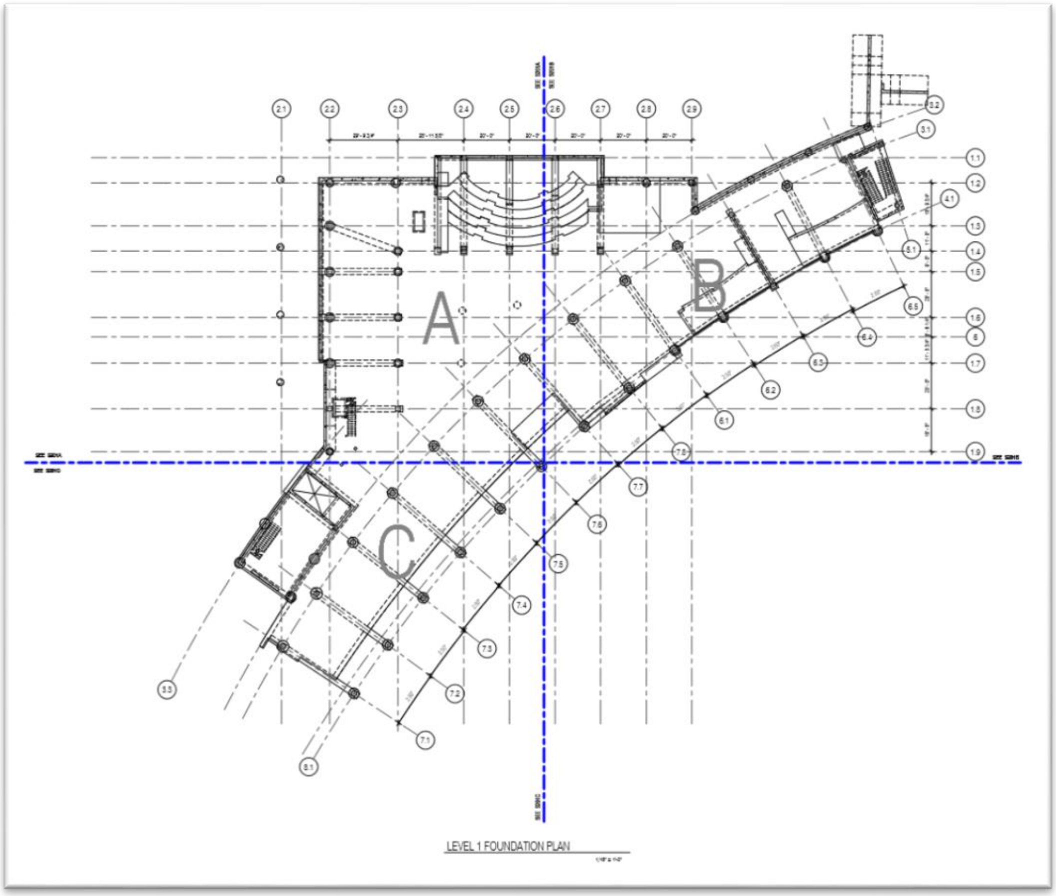
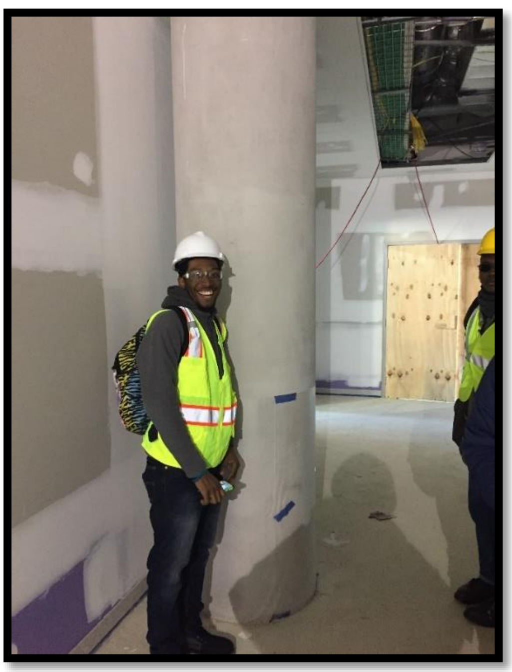


Figure A4: Overview of the fist floor foundation plan (Cagley and Associates)

Here in Fig. A5, the concrete pillars can be seen. These pillars bear on the location of the drilled piers (caissons).

Figure A5. Concrete columns, supported by the drilled piers (Caissons) underground.

The pillars support the built up concrete post tension beams and floor slabs, as seen below from the underside of the post tensioned slab (Fig. A6). The mechanicals are also suspended by an anchoring system from the post tensioning slab.



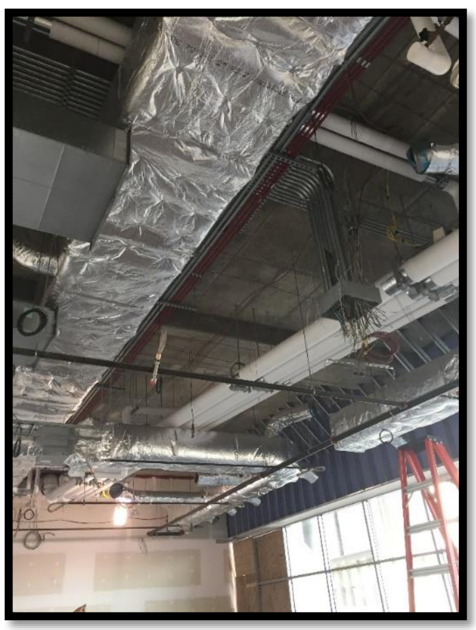


Figure A6. Underside of post tensioned slab

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The foundation was built on drilled piers or caissons based on 80 KSF Maximum net allowable end bearing pressure (Structural Plan p. S001). The caisson design is per standards laid out in the "Specification for the construction of drilled Piers, (ACI) American Concrete Institute 336.1.

The caisson design (seen in detail in figure A7) were based on the required structural loads however the depth of the caissons was based on the results of the geotechnical report of the soils.

The geotechnical report outlines many pertinent details that effected the design of the structure. The first aspect of the Geotechnical report is the reginal geology. Here, the soil characteristics are described as existing fill soils, coastal plain deposits, residual soils, disintegrated rock, and bedrock. The existing fill is proposed to be a result of the previous site grading from the demolished shopping center. The coastal plain deposits are classified as Patuxent Formation soils of primarily sand and clays. The report identifies the parent bedrock as the Baltimore Gneiss of the Piedmont Formation. Test borings were done to evaluate the geotechnical properties of the soil. 18 test borings were made using the Standard Penetration Test (SPT) and were obtained using a hydraulically driven Automatic Trip Hammer (ATH).

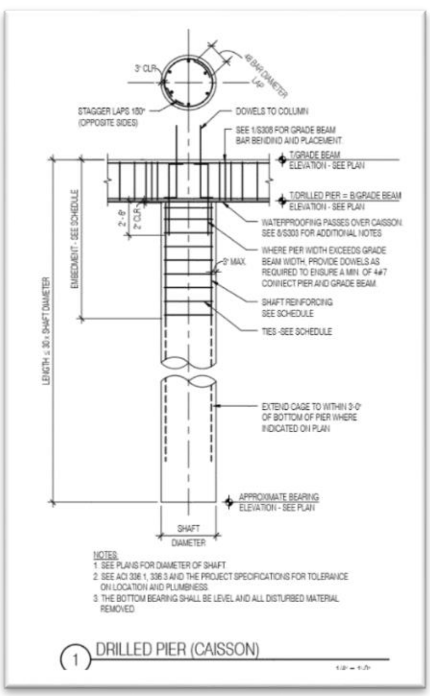

Figure A7: Caisson design

The SPT results were categorized into the following stratigraphy or layers of soil (Table A1). The analysis of the quality and depths of the soils was used to determine the depth required to bear the caissons on bedrock.

Table A1: Summary of Results from the SPT

Stratigraphy/Layer	Extension	Depth below ground surface	Soil Types Identified	Penetration Test Blows/FT (N)	Moisture Content
Groundcover		0-12 inches	Asphalt/ Crushed Aggregate	Not Given	Not Given
Stratum A	Fill/Probable Fill Soils	8.5-32.5 feet	Silts, Lean Clay, Silty Sand, Poorly Graded Sand, Clayey Gravel, and Clayey Sand	N=2-30 bpf (loose to dense) N=3-30 bpf (soft to hard)	Not Given
Stratum B	Patuxent Formations	10-32.2 feet	Lean Clay(CL), Poorly Graded Sand(SP), Silt(ML/MH), Sandy Silt(ML), Silty Sand(SM)	N=6-37 bpf (Variable Soil consistency)	19.6-22.3%
Stratum C	Residual Soils	23.5-63.5 feet	Silt(ML), Silty Sand(SM), rock fragments, mica, Poorly graded Sand(SP)	N=2-53 bpf (variable soil consistency)	28.9%
Stratum D	Disintegrated Rock	29-65.5 feet	Disintegrated Rock (residual Earth Material)	N=60 bpf - auger refusal	Not given
Stratum E	Baltimore Gneiss (Bedrock)	Elevation 210-222 (sloping)	Bedrock	RDQ 47-100% (Rock Quality Designation)	Not Given

The test borings are used to generate cross sections like the one pictured below (Fig. A8). These cross sections provide a good visualization of the soil layers and their corresponding elevations (Fig. A9).

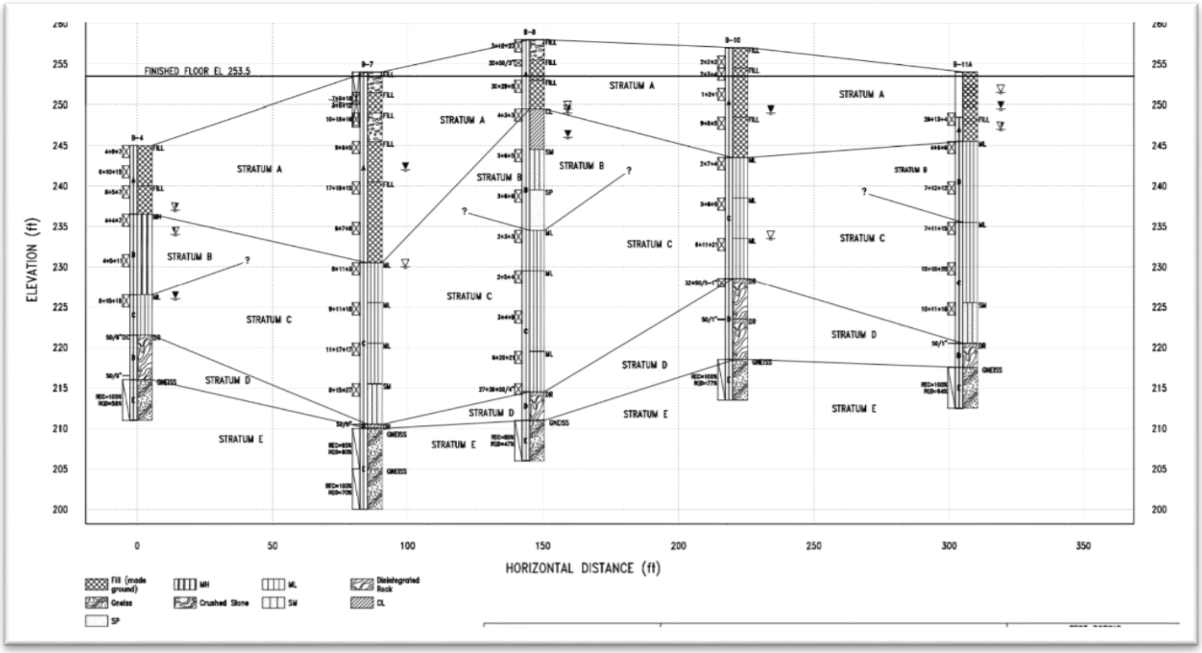

Figure A8: Cross section of test borings

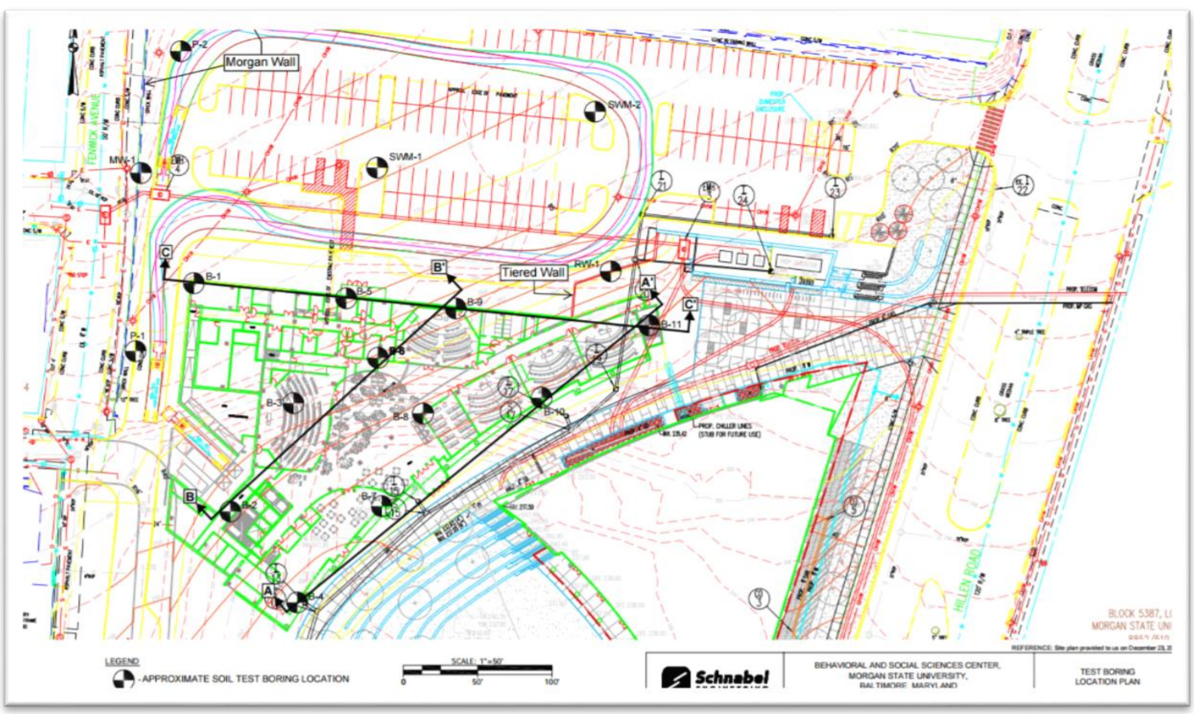

Figure A9: Plan overview of boring locations

Because of the high level of uncertainty of the quality of the fill, Schnabel Engineering did not recommend that the existing fill be used for direct support of the floor slab (p.12). This was a critical determination because it required the subsequent use of caissons bearing directly on the bedrock to support the foundation and superstructure.

The use of ground level foundation beams (Fig. A10) were incorporated into the design to avoid bearing directly on the fill.

Additionally, the groundwater readings indicated groundwater at EL 253.5 the same level of the lowest floor. This required the construction of the below slab drainage system that Ms. Wilson mentioned on the site tour. The intent is to maintain groundwater levels below the first floor.

In conclusion, this report has given me a much greater understanding of the importance of proper geotechnical analysis. I learned a great deal about the different types of soil and the Standard Penetration Test process. Also, I have come to a much greater appreciation of the steps and complexities that geotechnical engineers face to ensure the design is safely supported. "

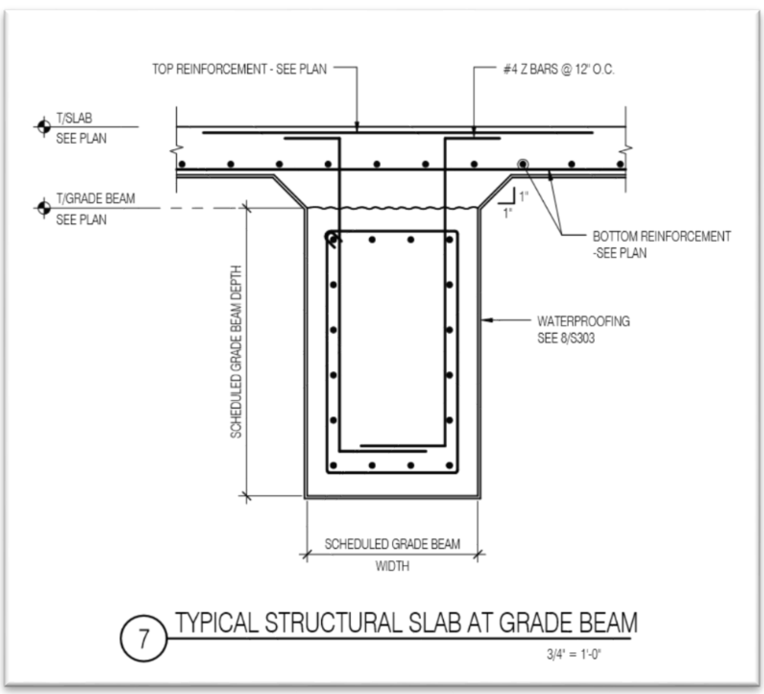

Figure A10: Ground Level Foundation Beam