Gearing up for Transportation Engineering, A Summer Institute: Phase IV

By

Kathleen M. Leonard, Ph.D., Michael Anderson, Ph.D.,
Lois Schwarz, Ph.D., and Houssam Toutanji, Ph.D.
Civil & Environmental Engineering Department
The University of Alabama in Huntsville
Huntsville, Alabama

And

Norb Delatte, Ph.D.
Civil & Environmental Engineering Department
The University of Alabama in Birmingham
Birmingham, Alabama

Prepared by

UTCA

University Transportation Center for Alabama
The University of Alabama, The University of Alabama in Birmingham,
And the University of Alabama in Huntsville

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16. Abstract

The numbers of female and minority students enrolled in engineering schools are increasing slowly, however there is still a relatively small percentage drawn to the field of transportation civil engineering. As a consequence, there is a need to educate young people about the profession to encourage them to appreciate the contributions of engineers and to become civil engineers. This is especially true for under-represented groups. This Summer Institute project consisted of inviting forty middle school students to the University of Alabama in Huntsville campus to learn about engineering as a career and experience a variety of transportation engineering design topics. The participants gained knowledge about the role of engineers in society as well as learned how engineers use their knowledge in design applications. Several University of Alabama faulty members and Society of Women Engineer professionals acted as team mentors. As an important part of this project, local minority and female engineers served as mentors for the program. This is the fourth year of the summer program at UAH.

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Contents

List of Tables

List of Figures

Executive Summary

The number of students enrolled in engineering schools is increasing slowly; however, there is still a relatively small percentage drawn to the field of transportation engineering. As a consequence, there is a need to educate young people about the profession, to encourage them to appreciate the contributions of engineers, and to encourage them to become civil engineers. This is especially true for young people from under-represented groups. This summer institute project consisted of inviting two groups of twenty-two middle school students to the University of Alabama in Huntsville (UAH) campus to learn about engineering as a career and experience a variety of transportation engineering design topics. The participants gained knowledge about the role of engineers in society as well as learned how engineers use their knowledge in design applications. Five University of Alabama System engineering faculty members, as well as professionals representing the Society of Women Engineers (SWE), NASA Marshall Space Flight Center, and the National Society of Black Engineers, acted as instructors for the hands on laboratories. As an important part of this project, several minority and female engineering students served as mentors for the program.

Section 1
Introduction

Problem Statement

Objectives

The number of students has been increasing overall in engineering and science (National Commission on Excellence in Education. 1983); however, there is still a relatively small percentage drawn to the field of civil and transportation engineering. As a consequence, there is a need to educate young people about the profession to encourage under-represented individuals to become engineers and contribute to transportation technology.

Approach

The major goal of this program was to introduce middle school students to basic engineering and transportation-related concepts, with preference given to students from under-represented groups. An additional approach of the project was to draft local minority and female engineers to act as team instructors and mentors. Participants used real world examples and new technologies in their hands-on activities to reinforce the concepts presented by the engineering mentors. A final comprehensive team project was used to tie all the knowledge together in a design competition.

Section 2
Background

In past years, the University of Alabama in Huntsville (UAH) and the American Society of Civil Engineers (ASCE) worked with local schools in the Huntsville, Madison County and Morgan County area and became aware that local public schools do not have any formal relationship with the engineering academic and technical community. In addition, all those school systems have a high ratio of minority students, approximately 25% of total enrollment. As a consequence, local county middle and “science magnet” school principals and teachers were asked to nominate students for this Summer Institute. Preference was given to students that are under-represented in the transportation engineering field (female and minorities). This year a week was dedicated to a “girls only” forum and the Girl Scouts of North Alabama was invited to nominate participants. A committee consisting of representatives from each of the participating groups selected twenty participants based on potential rather than classroom grades.

This Summer Institute project consisted of bringing selected middle school students to the UAH campus to learn about various aspects of engineering and experience transportation-related design and safety topics. This opportunity may encourage them to consider civil and transportation engineering as a career option and increase diversity of the workforce, a problem in some areas of the country (U.S. DOT, 2000).

Section 3
Methodology

Science Teaching Method

Recent efforts to reform science education in schools have led to the development of the Science/Technology/Society (STS) teaching method. Some important aspects of the STS method are that students must feel a concept is personally useful for solving specific problems, and that students who learn through an experience will retain information and will be better able to apply the information later to new situations. Instructional and interactive experiences were developed with this grant to motivate interest in transportation engineering and related science topics. The program was initiated in the Gearing Up for Transportation Engineering Program (GUTEP) Summer Institute in 2000. The current year's program refined the laboratory activities and put the manual on the UAH UTCA Web site as a teacher resource.

The strategy of this program was tot produce students who know "how to find out" and "how to examine and evaluate evidence." As discussed in the first year's UTCA final report [Leonard, et al., 2000], the following criteria were used in designing the hands-on experiments:

- The activities were designed so that the students could complete them by themselves; they were not demonstrations performed by the instructors for the class.
- Students had to be able to read, perform and document the experiments themselves with limited adult supervision.
- Each experiment was designed so that the results were sufficiently dramatic to keep the students' attention with a high probability of success.
- Experience has shown that middle school students work best in teams, so the activities and equipment were appropriately structured.
- In general, each experiment took approximately 1-1.5 hour including set-up, clean-up, and follow-up discussions to highlight concepts and results.
- Safety and good lab protocol were practiced and stressed throughout.

To accomplish these goals, students were encouraged to use the following design heuristic in their team transportation problem:

1. Define the problem
2. Generate possible solutions, using brainstorming and other creative thinking techniques
3. Decide on a course of action
4. Integrate the solution
5. Evaluate the solution

The following list of national science education standards' topics (National Research Council, 1998) and skills was used as a template for the Gearing Up for Transportation Engineering Program (GUTEP) activities. Attention to appropriate skill level was a major factor in the preparation of these activities.

Physical Science: Motions and forces, Transfer of energy

History and Nature of Science: Science as human endeavor, Nature of science, History of science

Science as Inquiry: Abilities necessary to do scientific inquiry, Understandings about scientific inquiry, Develop descriptions, explanations, predictions, and models using evidence

Science and Technology: Abilities of technological design, Design a solution or product, Implement a proposed design, Evaluate completed technological designs, Abilities of technological design, Understanding about science and technology or products

Science in Personal and Social Perspectives: Science and technology in society, Populations, resources, and environments

Unifying Concepts and Processes: Evidence, models, and explanation, Form and function

Science Process Skills: Collecting Data, Constructing, Inferring, Measuring, Communicating, Making Models, Interpreting Data, Controlling Variables, Investigating

This project met the UTCA goals of increasing human resources and increasing diversity in the transportation field, and thus affects Alabama's future human resource population, by using technology transfer through focused educational activities.

Section 4
Project Results

Tasks Completed

This project had a one-year duration commencing January 2003. The following tasks were completed to achieve the desired goal of transportation education through technology transfer.

Recruiting

Letters were sent to schools, phone calls were made to science teachers and follow-up contacts were made. The Girl Scouts of North Alabama event coordinator, Ms. Becky Hodges, was instrumental in contacting parents and helping to select candidates for the GUTEP program. The program committee met to select 44 students based on potential and interest levels, with preference given to under represented groups.

Schedule Mentors

The Principal Investigator contacted professional organizations (National Society of Black Engineers, Society Women Engineers, and American Society of Civil Engineers), college chapters of the societies, NASA Marshall Space Flight Center, local companies (Boeing and Sverdrup), and the Huntsville Center of US Army Corps of Engineers.

Set-up schedule and lab experience

a) The principal investigator met several times with instructors to discuss the objectives of each lab experience.
b) Professors were asked to update their individual experiments as indicated by last year's survey results.
c) Trial runs were conducted on the labs with several middle school students prior to GUTEP.
d) Finalized laboratory instructions were received from co-Principal Investigators.
e) Supplies were obtained and student manuals were collated.
f) Rooms were reserved on campus and field trips were scheduled.

Summer institute

Week 1: June 9-13, 2003; Week 2: July 24-28, 2003

a) Students were divided into five teams of four students each, to conduct labs concurrently.
b) The adopted schedule (see Appendix A) was followed for activities.

b) On Friday of each institute, participants gave demonstrations and oral reports on their team's future transportation design.

Après program

a) Thank you letters and certificates were sent to instructors and field trip sponsors.
b) The participant surveys were compiled and analyzed.
c) The instructors met to discuss ways to improve program for subsequent years.

Deliverables

a) The Institute manual was completed for use by the students and as a teacher resource. All five investigators were responsible for completing their laboratory experiment documentation as part of the manual.
b) The manual was posted on the UAH UTCA web site in html format (http://coeweb.eb.uah.edu/cee/utca.htm).
c) The Principal Investigator was responsible for quarterly reports to UTCA. The final report was completed and sent to UTCA in December 2003.

Synopsis of Student Hands-On Experiments

GUTEP was scheduled and run for two one-week sessions on the UAH campus. The mornings were informative sessions, followed by lunch. The afternoon activities were characterized by more "hands on" experiences, such as design projects and laboratories. The last day concentrated on team building and a "vehicle of the future" design project. A summary of each laboratory experience follows and the new geotechnical experiment is included in Appendix B. Photos from the Institute are included in Appendix C

1. Traffic Simulation

Objective: To learn about the traffic engineering concept, level-of-service, and how traffic engineers use micro-simulation to analyze roadway intersections and design city streets.

Description: In this activity, students explore traffic micro-simulation and determine existing and future levels of service for different roadways systems. The students learn about highway design principles related to intersections and traffic signal control.

2. Space Transportation

Objective: To demonstrate how rocket liftoff is an application of Newton's Laws of Motion. Students also will learn about the history and future of space transportation in the USA (NASA, 2000).

Description: To demonstrate how rocket liftoff is an application of Newton's Laws of Motion. Students construct a rocket powered by the pressure generated from an effervescing antacid tablet reacting with water. Students also use the NASA disk "Space Transportation: Past, Present and Future" to learn about space applications.

3. Construction Materials

Objective: To learn about different types of materials used for roads, bridges, parking lots, dams, and buildings.

Description: In this activity, students learn about engineering materials used in transportation, such as wood, metals, concrete, pavements and composite materials. They prepare and test some of these materials.

4. Engineering Shapes (New this year)

Objective: To learn how to enhance the strength and stability of simple structures.

Description: In this activity, students build and test a column, dome and truss and make predictions on loads.

5. Alternative Energy

Objective: To explore alternative energy sources, other than fossil fuels, for future transportation modes. Also, to stress the importance and effectiveness of alternative energy sources.

Description: In this activity, students perform experiments using a solar cell. They observe the physical power of light/heat absorption through a small free moving device with black and white panels. Each student constructs a battery powered fan boat.

6. Bridges

Objective: To learn about different types of bridges by building simple models.

Description: In this activity, students construct a simple span bridge. They use an interactive computer simulation model to design a suspension bridge to carry the load of a truck. They also build a scale model of their bridge design.

7. Geotechnical Materials (new for 2003)

Objective: To understand how soils behave under loading.

Description: This activity is a simple demonstration of the behavior of a layered soil system and load carrying ability of the system for dynamic loadings similar to wheel loads imposed by traffic.

8. Transportation Safety

Objective: To explore issues related to automobile safety. They also learn ways to design safety into cars**.**

Description: In this activity, students learn about bike, bus and auto restraints safety. They also perform experiments illustrating safety features using eggs

9. Future Transportation Design Problem

Objective: To design and build a working model of the team's vision of a future transportation vehicle.

Description: In this activity, students design a prototype of a vehicle of the future. They construct a working model with motorized K'nex kit. It must meet energy, safety, and infrastructure constraints.

Field Trips

Past Modes of Transportation – North Alabama Railroad Museum, Big Spring Canal
Current Modes of Transportation – Huntsville Shuttle (mass transit system) and Huntsville Hospital tram
Transportation Engineering – City of Huntsville Engineering and Sign Shop
Future Modes of Transportation – NASA Marshall Space Flight Center's ANVIL research center Introduced to virtual reality and space station mock-ups.

Seminars

History of Transportation Engineering
Team Building Skills

Goals Met By the Institute

The major goal of this program was to introduce middle school students to basic scientific and engineering concepts, with preference given to those from under-represented groups. These groups have potential for science and engineering, but might lack role models and motivation to pursue a career in transportation engineering. The selection committee used the teacher references to rate the students (criteria were student statements of interest and teacher comments, and ethnicity). As a result the UTCA summer program was successful in recruiting 72% minority students (African American, Asian and Hispanic) and 44% female students for the first week. The second week was 100% female with 22% minority students for the program. The ethnicity breakdown is given in Table 4-1.

Table 4.1 Participants Ethnicity Information

	Week 1			Week 2		
	Female	Male	Percent	Female	Male	Percent
Total number	10	12	100%	4	0	18%
African American	5	9	64%	4	0	18%
Asian	0	1	4%	0	0	0%
Caucasian	5	1	27%	17	0	77%
Hispanic	0	1	4%	1	0	4%

Significance and Benefits of the Program to Participants

The participants gained knowledge about the role of transportation planning, management, safety, and design in modern society. The emphasis was on how engineers use their knowledge in design applications. The last day of the Summer Institute concentrated on a team design in transportation engineering, where they combined the knowledge acquired in the laboratory experiences. A faulty member or professional acted as each team's mentor and helped them to prepare an electronic and oral presentation of their design. Students in the winning design team were awarded the K'nex kits and all participants received certificates of accomplishment from UAH at the closing ceremony. All the students received a prize of some kind, from the safety challenge, bridge design, rocket launch, etc., which helped to instill a sense of accomplishment and pride.

Since the middle school curriculum contains hard science and algebra, which are directly related to engineering, this program enhanced classroom instruction with "hands on" experience. In addition, the principal investigators and professionals that acted as team mentors also functioned as role models, especially for minority and female students. This may help to increase the numbers of these students that will go on to become transportation professionals. The use of UAH minority and women engineering students as lab assistants encouraged them to become involved in the community as professionals.

The program was intended to be a fun learning experience with a lot of basic information, team building skills, and hands-on laboratory experience of the latest transportation safety and management technology. On the last afternoon of the program, the students were asked to complete a program survey form. Table 4-2 shows the results.

The favorite experiments (three-way tie) were alternative energy (battery powered fan boat), concrete materials (concrete bowling ball), and bridges (design and build popsicle stick bridge). These will remain unchanged in the upcoming program. The least favorite, soils and traffic simulation will be updated with activities that are more dynamic and more fun. The students were also asked about their enjoyment of the program. All of them answered affirmatively to questions regarding recommending this program to a friend (100% said they would attend a similar program next year) and that the field trips and experiments increased their knowledge of engineering (question 7). The final question indicated their own views about engineering as a future career for them. Approximately 85% thought that they might choose engineering as a profession.

Table 4-2 Participants' Survey Results

Survey Questions	Choice	
What was your favorite experiment?	Concrete, Bridges, Alt Energy	
What was your least favorite experiment?	Soils, Traffic	
What was your favorite field trip?	HSV Shuttle bus Huntsville sign shop	
What was your least favorite field trip?	Airport intermodal	
	Yes	**No**
Would you recommend this program to a friend?	97%	3%
Would you attend a similar program again	100%	0%
Do you feel like the field trips and experiments contributed to your learning experience?	97%	0%
Did the program increase your knowledge of what transportation engineers do?	97%	3%
Would you consider becoming an engineer?	85%	15%

This year the construction materials (concrete bowling balls) and bridges labs were also used for a group of high school students who visited the university in late July. They were successful for these older participants with the addition of cost constraints on their bridge designs.

Advantages for participants

- fun and enjoyable exposure to science, engineering and transportation technology topics
- development of thinking and problem-solving skills
- participants learn what civil engineers do and their contributions to society
- meaningful and immediate experimental learning
- fuel for their natural curiosity
- self-directed learning opportunities in team design
- increased self-esteem from completion of institute
- multiple exposure to difficult topics and inter-relationships to transportation issues
- opportunity to learn within academic facilities – may take away fear of technology
- diversity of mentors help students feel comfortable at institute

UAH Student Involvement

The project employed four undergraduate student assistants and two graduate students (both minorities and females) to help in designing the projects, documenting plans, laboratory set-ups, and assist with the participating middle-school students at the Institute. Other university students acted as laboratory volunteers through the SWE, ASCE and NSBE student chapters.

Section 5
Project Conclusions

Education and Technology Transfer Activities

The team members completed the lab activities' manual (both teacher instruction and student activity guides) for implementation at school visits and for next year's program. A Web page was posted through UAH - UTCA home pages to allow on-line access.

Research relevance and impacts to Alabama

This project addressed the mission and several of the major goals of UTCA. In addition to providing educational experiences for middle school students within Alabama, the project addressed human resources and diversity issues. This program has the potential to affect the future workplace since students may wish to become involved in working on transportation-related research at an early age and thus may gravitate towards the profession as they mature. The project also addresses the technology transfer goal of UTCA since student assistants; mentors and participants were exposed to state of the art technology within the university curriculum.

After the program was finished the students completed a survey, and all thought that the program was fun and educational. Most of them did not know what transportation engineers did prior to coming to UAH and were surprised at the many variations. Finally, they would all recommend the program to their friends.

Recommendations for Next Program

The survey results will be helpful in composing next years' summer program. The two least favorite labs will be updated with new material and an additional lab will be added. Otherwise the program will be similar to the 2003 GUTEP.

Section 6.0
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APPENDIX A

Sample of Program Schedule

"GEARING UP FOR TRANSPORTATION ENGINEERING SUMMER INSTITUTE"

SUMMER 2003

Field Trips

Past Modes of Transportation (Wed)

North Alabama Railroad Museum - Chase, AL

Current Modes of Transportation (Thurs)

Huntsville Shuttle Service (Mass Transit)
Huntsville Hospital tram operations
Huntsville Transportation office – Intelligent transportation System

Future Modes of Travel (Tues)

NASA – Virtual Reality tour

Hands-On Sessions (4 Groups of 5 students each)

Event Title and Coordinator	***Room***
1. Traffic Simulation - (Anderson)	TH S242
2. Space transportation -- (Leonard, SWE)	TH S208 & 206
3. Construction Materials -- (Toutanji	TH S207
4. Engineering Shapes - (Leonard)	TH S239
5. Alternative Energy/Boats (Leonard)	TH S201
6. Bridges - (Delatte)	TH S208
7. Geotechnical Materials --(Schwarz)	TH N224
8. Transportation Safety - (Anderson)	TH S207
9. Designing the Car of the Future (All)	TH S105

Daily Schedule

Time	**Monday, 9th**	**Tuesday, 10th**	**Wednesday, 11th**	**Thursday, 12th**	**Friday, 13th**
9:00-10:00	Introduction Team Building	History of Transportation	RR museum	HSV Shuttle service City Eng.	Concrete BB: Team Design
10:00-11:15	Robot cars	NASA	Ride		Project
11:15-12:00	*Lunch - Pizza*	*Lunch – UC*	*Lunch - Picnic*	*Lunch – BK*	*Lunch – Pizza*
12:00 -1:45	Exp 7,2,3,4	Exp 7, 2, 3, 4	Exp 5,6,1,8	Exp 5,6,1,8	9. Design
1:45- 2:00	Break	Break	Break	break	Competition
2:00-3:45	Exp 7,2,3,4	Exp 7, 2, 3, 4	Exp 5,6,1,8	Exp 5,6,1,8	Awards
4:00	Depart	Depart	Depart	Depart	Depart

APPENDIX B
Copy of New Experiment (Number 7)

7. Geotechnical Materials: Mud Pie Magic

Hey Guys!

It's time to have fun playing with mud! In this activity you will learn about the principles of soil compaction and the behavior of layered soil systems when supporting a dynamically applied load.

Background:

Structures of all types including buildings, bridges, and roadways are built on top of geo-materials, or the ground, which is made up of different layers of soil and rock. Depending on the type of soil, the amount of water present, and the tightness of the particle packing, soil can support a load without showing signs of settlement or deformation. Geo-materials are usually compacted to improve their density and strength; that is, mechanically eliminating the air space between individual soil particles and packing them tighter will increase the ability of the soil to support a load and reduce undesired settlement. The ability of soils and rock to support applied loads is very important in the design of foundations, whether they are under a 100-story building or an interstate highway. Settlement can cause severe structural cracking and even collapse in buildings, towers, or bridges and also severe roadway damage including rutting, cracking, and potholes (and not the pothole bandit!). A classic example of poor soil conditions is the famous leaning tower of Pisa in Italy. This structure is leaning 5 degrees from vertical, causing the top of the tower to be 17 feet off plumb, due to uneven settlement of the wet unconsolidated soil layers that are underneath.

This activity is a simple demonstration of the behavior of a layered soil system and load carrying ability of the system for dynamic loadings similar to wheel loads imposed by traffic.

Materials and Tools
Geo-materials
Water
Container
Packing tools
Scale
Dynamic load test-falling weight
Rule

Instructions

1. Instructor will introduce the principles of compaction and improvement in the ability of a soil system to support a dynamic load.

2. First, you will compact a layer of wet soil in the container, representing the ground that will underlie a roadway. Record the weight of soil and the weight of water used. Use both numbers to determine the nominal water content of the soil. Mark the height of the layer all around the side of the container.

3. Next, you will add a second layer, representing the subbase, using a different geo-material and amount of water. Record the weight of soil and water for this layer, determine the water content, and mark the layer height on the container.

4. Now add a third layer, representing the base, using another material and water. Again, record the weight of soil and water content for this layer and mark the layer height on the container.

5. OK! Now the fun begins with applying the load. You will test your compacted soil system by repetitively dropping a weight to simulate a dynamic wheel load. Align your sample in the apparatus and allow the weight to free fall twenty (20) times onto the soil in the container. Remove your container of soil from the loading area. Trace the demarcation of each layer around the container. Measure the original depth of each layer and the average depth of each layer after load testing. Determine the change in each layer thickness and note if you see any migration or mixing of individual soil layers.

7. Geotechnical Materials Report Sheet

Group Name: ________________________________

(a) Soil Layers and Compaction

1. Decide if you want to add a moderate amount of water to the soil, a little water, or use the soil as is (air-dry).

2. Compact the subgrade soil, and water if you choose, in the container. Write in the table below the weight of soil and the weight of water you added. Calculate the nominal water content as: (weight of water)/(weight of dry soil) x 100. Remember to trace the layer boundary on the sides of the container.

3. Pick another geo-material to use for the middle of your three-layer soil system. Decide if you want to add water to the soil or use dry.

4. Follow step 2 with your second layer.

5. Repeat step 3 and then step 2 for your top layer of soil.

SOIL LAYER	SOIL DRY WEIGHT (g)	WATER WEIGHT (g)	WATER CONTENT (%)
1 Subgrade (bottom)			
2 Subbase (middle)			

7. Geotechnical Materials Report Sheet

Group Name:_________________________________

(b) Ability of Soil Layers to Support a Dynamic Load

1. Carefully drop the load twenty (20) times onto your soil system. Let the weight free-fall, that is, do not hold back on the rope. Be sure that you raise the weight to same height for each drop.

2. Trace the boundaries of each layer on the sides of the container after load testing is complete. Measure the original depth of each layer and write your results below.

3. Measure the height of each layer after loading. Be sure to measure where the layer looks the smallest. Make this measurement on each of the four sides of the container. Record these numbers in the table. Next, average these four numbers. Determine the percent change in layer thickness for each layer as: (original thickness – final thickness)/(original thickness) x 100.

Layer	Original Height(cm)	Final Height (cm)	Percent Change (%)
1 (subgrade)			
Side 1			
Side 2			
Side 3			
Side 4			
Average			
2 (subbase)			
Side 1			
Side 2			
Side 3			
Side 4			
Average			
3 (base)			
Side 1			
Side 2			
Side 3			
Side 4			
Average			

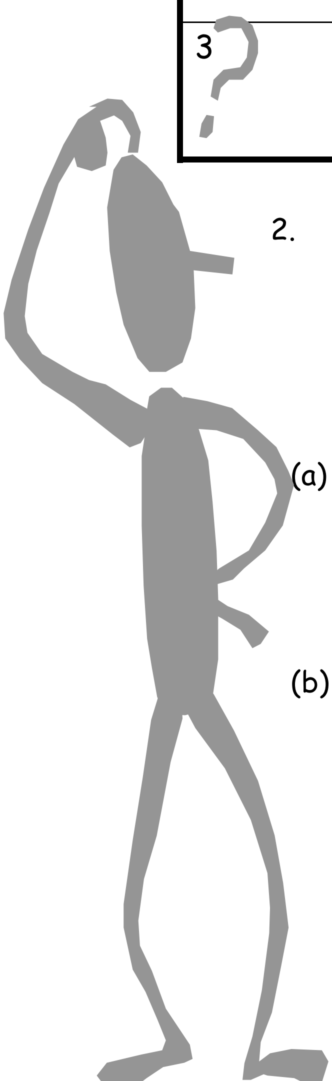
7. Geotechnical Materials Report Sheet

Group Name:_________________________________

(c) What do your results tell you?

1. In the table below, summarize your data.

Soil Type	**Moisture Content (%)**	**Change in Heigh (%)**	**Notes on Experiment: Observations**
1			
2			
3			



2. Ideally, the soil system should not show signs of the different layers intermingling or migrating and the layer thickness should not change. Change in layer thickness is evidence of settlement (deformation) and/or particle migration. Deformation of a layer is undesirable and will result in rutting of the roadway pavement, cracking, and potholes.

(a) Did your system of soil layers remain the same after the load test? Did you have deformation? Which layer was the worst?

(b) What could you do to improve the load carrying capacity of the system?

APPENDIX C
Photos from GUTEP 2003

Figure C1: Acid River – team building exercise

Figure C2: Alternative energy – fan boats

Figure C3: Car of the future

Figure C4: Shuttle bus field trip

Figure C5: GUTEP participants - Coed Week

Figure C6: GUTEP participants - Girls' Week