Coastal REsearch And Transportation Education
Tier 1 University Transportation Center
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CREATE: University of Miami's National Summer Transportation Institute (UM NSTI)

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16. Abstract

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DISCLAIMER

ABSTRACT

The University of Miami hosted the NSTI program to encourage the younger generations into the STEM disciplines and coastal transportation infrastructure. Activities included lectures, laboratory hands-on activities, and fun competitions related to coastal transportation infrastructure. Participants engaged in science rich activities, and develop critical thinking, teamwork, and career development skills.

Keywords: Coastal Infrastructure; Transportation Materials; STEM

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INTRODUCTION

The program was designed to offer an engaging and impactful summer experience that introduced students to the core principles, real-world applications, and challenges of STEM fields. Through a combination of lessons, group projects, and team-based competitions, participants gained both knowledge and hands-on exposure.

Students began by learning the basic principles of engineering before moving into the field of transportation engineering. They explored the materials used in different modes of transport, examined the role of safety in transportation systems, and discussed the variety of structures and vehicles that support mobility. The program also highlighted recent technological innovations shaping the industry.

Beyond land transportation, students were introduced to water- and air-based systems. They studied the engineering behind ships, ports, and canals, as well as the design of airport terminals and aircraft. Throughout these sessions, the emphasis remained on safety practices and the development of essential technical skills critical to careers in the transportation sector.

The program also emphasized the importance of time management by setting strict limits on activities and requiring students to arrive promptly each day. Sessions were designed to be highly interactive, with instructors posing challenging and thought-provoking questions to encourage critical thinking and sharpen analytical reasoning.

PEDAGOGY AND ACTIVITIES

Interactive Lectures

The program began with an introduction to the history of transportation, tracing its evolution from 7000 BC to the present day. Students were encouraged to reflect on how key technological milestones, such as the invention of the wheel, the development of highways, and the advent of aviation, revolutionized mobility in their respective eras (Figure 1).

Following this, the focus shifted to structural engineering, where participants learned about bridges and trusses. They explored different bridge types, including beam, arch, and suspension bridges, while also examining the scientific principles of forces, stability, elasticity, and failure modes like buckling and snapping. Core concepts in mathematics, physics, and statistics were also introduced as foundational elements of engineering.

Another highlight was the discussion on nanotechnology in transportation. Students discovered how nanoparticles like titanium dioxide can impart self-healing and self-cleaning properties to materials. Real-world applications, ranging from coatings and asphalt to concrete sound barriers, were showcased to illustrate their versatility. These innovations were presented as

Figure 1: Images showing various interactive lectures.

transformative tools for extending material durability and improving the resilience of modern transportation infrastructure.

The program also emphasized laboratory safety and the broader importance of safety practices in transportation engineering. Students explored strategies for improving safety and communication, analyzing and predicting emerging issues, and understanding the benefits of secure transportation systems. Topics covered included pedestrian and cyclist protection, aviation safety, and vehicle-related safety measures.

Another area of focus was marine transportation, where students were introduced to the structure and operation of the maritime system. They learned about its high energy efficiency and impressive cargo-handling capacity, as well as challenges such as oil spills. The discussions included methods of moving people and goods through waterways, from deep-sea freight and passenger transport to local services, marinas, and cargo handling. Basic scientific concepts like buoyancy and air pressure were also explained to help students understand vessel design and function.

Finally, the program introduced polymers and hydrogels, giving students hands-on demonstrations of their properties. Their wide range of applications in the transportation sector was highlighted, along with the science behind their performance, such as osmosis and the capillary effect.

Transportation projects heavily rely on both polymers and metals, each offering distinct advantages. Students compared the two classes of materials, learning about differences in mechanical strength, durability, and deformability. The discussion emphasized how innovative materials are increasingly essential for improving infrastructure and vehicles, from highways and bridges to aircraft and ships.

The program also examined air transportation, focusing on how materials used in aircraft must endure rigorous performance standards. Through lecture and multimedia, students explored the concept of material failure in airplanes. This reinforced the importance of material science, safety, and engineering rigor in the aviation industry.

Hands-on Activities

The initial laboratory exercise allowed students to put their new engineering knowledge into practice by designing, building, and testing small Balsa wood truss bridges. Working in pairs with limited resources encouraged collaboration, creativity, and problem-solving under constraints.

Following this activity, students transitioned to the Materials and Structures Laboratory, where they collaboratively prepared cement paste samples enhanced with nanomaterials. After a brief curing period, the samples were subjected to compressive strength testing. Through these experiments, students not only calculated mechanical strength using peak load data but also observed how the cement paste responded under compression. They later compared results from standard and nanomaterial-modified pastes to evaluate performance differences (Figure 2).

Students applied their learning by designing and constructing small cement paste. They were given the freedom to select their own mix proportions and adjust the thickness of the material based on their design choices. Through this exercise, students observed firsthand why some designs succeeded while others failed, gaining practical insight into material behavior and structural decision-making.

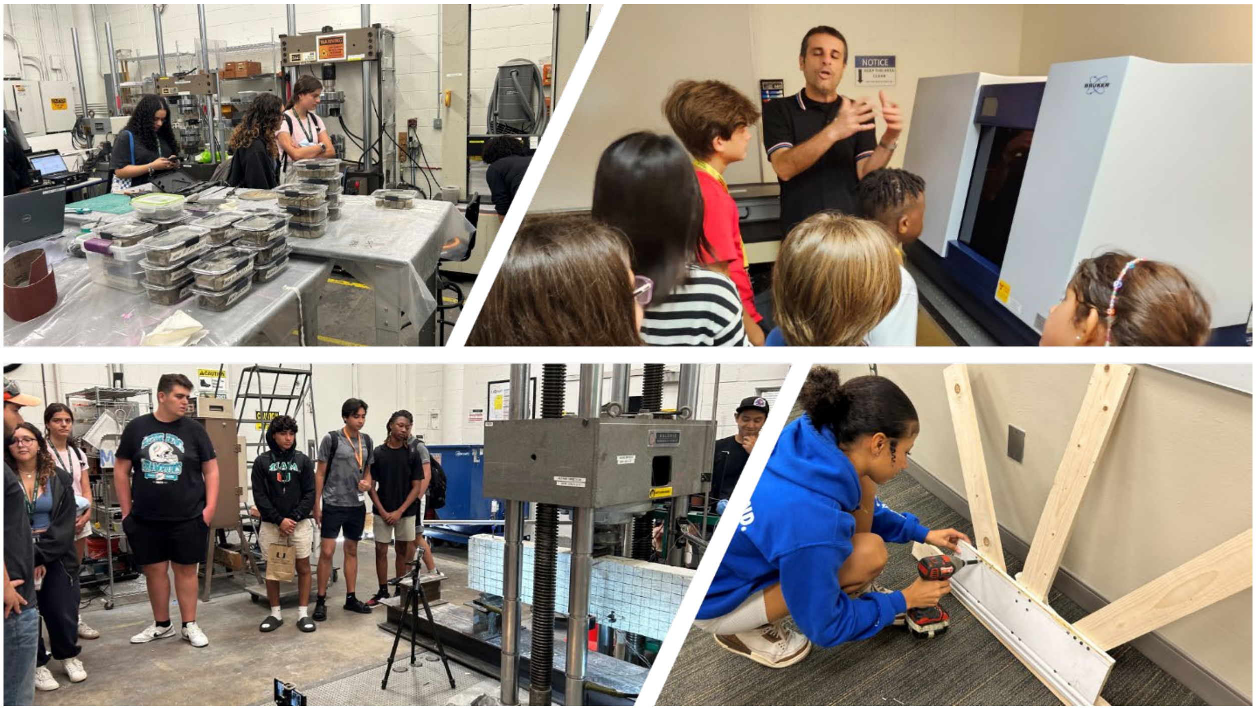

Figure 2: Images showing various hands-on activities.

Students visited the University of Miami's Advanced Microscopy Center, where they were introduced to the operation of an x-ray micro-computed tomography (Micro-CT). They gained an understanding of the role of microscopy across transportation-related fields and observed the microstructural features of concrete commonly used in transportation infrastructure.

In addition, the cohort explored additive manufacturing at the Manufacturing Engineering Laboratory. They learned how the printer processes a 3D file by slicing it into thin layers, which are then sequentially deposited from plastic material to form the complete object. The activity highlighted how thinner layers lead to smoother surfaces and greater accuracy. Students also discussed the wide range of applications of 3D printing in engineering and design, particularly in transportation, where it serves as an efficient tool for developing and testing prototypes.

ASSESSMENT AND OUTCOMES

Students participated in both pre- and post-program surveys to assess their understanding of transportation engineering and to measure the program's overall impact. The survey results indicated strong learning outcomes, with students reporting significant knowledge gains and a high level of satisfaction with the activities. Importantly, most participants expressed that, as a result of the program, they were more inclined to pursue a future career in transportation or related STEM fields.

REFERENCES

Not applicable.

IMPLEMENTATION

Not applicable.

ILLUSTRATIVE EXAMPLES

Not applicable.

RECOMMENDATIONS AND CONCLUSIONS

STEM outreach in coastal transportation infrastructure is vital for building a skilled workforce. Programs should engage students with hands-on activities such as designing resilient bridges, testing pervious concrete, and simulating storm impacts on ports and highways. Partnering with schools, resilience offices, and community organizations can broaden access. These initiatives cultivate interest in engineering and science while preparing students to address the urgent challenges of coastal resilience.

DATA AVAILABILITY STATEMENT

No data was collected for this project.

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REFERENCES

Not applicable.