

Civil Engineering

The Clemson University Glenn Department of Civil Engineering in Lowry Hall conducts research in Applied Fluid Mechanics, Construction Engineering and Management, Construction Materials, Geotechnical Engineering, Structural Engineering, and Transportation Systems. Having been a subject of study since the founding of the University in 1889, the Civil Engineering (CE) department offers a comprehensive undergraduate and graduate program leading to the BSCE, MS, or PhD degrees. Faculty specializations include areas such as applied fluid mechanics, Construction Engineering and Management, Construction Materials, Geotechnical Engineering, Structural Engineering and Transportation systems. The Civil Engineering Department has about 400 undergraduate students (not including freshmen) and 115 graduate students.

The department has 28 full-time faculty members, and 14 administrative, technical, and research staff members. All have separate faculty offices located within Lowry Hall in close proximity to the classrooms, to ensure easy access to students for purposes of enhancing interactions. The total faculty office space available is 4,987 square feet, with an average office space of 160 square feet. The department also houses the Risk Engineering System Analytics group (RESA), Transportation Technology Transfer Service (T3S), and two members of the CECAS Business Office.

The Civil Engineering Department has seven administrative staff members and two technical staff members, all housed within Lowry hall. The administrative offices of the Department have 1,432 square feet. The technical staff has office space of about 550 square feet and a machine shop that is about 900 square feet.

Since 2015 substantial upgrades have been carried out in Lowry Hall which is the home of the Glenn Department of Civil Engineering. These upgrades include improvements in classrooms and labs, and faculty offices. A list of the upgrades are detailed below:

First Floor Renovations

- Hallways: Flooring, ceilings, lighting, doors, monitors and signage
- ADA compliant restrooms
- Room 121 Executive Suite (glass walls, furniture, HVAC)
- Room 115 Classroom (flooring, ceiling, furniture)
- Room 100 Auditorium (abatement, flooring, ceiling, HVAC, electrical)

Further Renovations to Lowry Hall

- Room 18 Grad Office (abatement, ceiling, floor, new furniture)
- Room 30 Fluids Lab (new water sump, added wall, removed old wave tank)
- Room 217 Classroom (electrical)
- South Stairwell railing and handrails modified to meet code and improve safety
- Rooms 214/218 Offices (abatement, ceiling, floors, paint)

Lowry Hall has 8 Smart Classrooms containing Media Touch Panels, projectors, screens and white/glass boards. These classrooms are included in 25Live and Banner, and can be scheduled by any department. 25Live and Banner are the scheduling tools Clemson University purchased to help schedule, optimize, and allocate resources.

Laboratories

The Civil Engineering Department has 4 laboratories that are used for instructional purposes. The Department is continually investing in laboratory equipment in an effort to stay up-to-date. The laboratories available in the Department and the courses using them are discussed in the following sections.

Surveying Laboratory (Room 16 Lowry Hall)

The Surveying Laboratory is primarily used for CE 2550 Geomatics. This course addresses traditional surveying and other spatial data collection techniques plus spatial data analysis and processing methods. The surveying laboratory is primarily a storage room for the equipment used in the course. The room includes seven storage lockers, with each locker storing complete setups. Students are currently divided into groups of four; therefore, the room is designed to provide equipment for up to 28 students. The available equipment includes 100-foot measuring tapes (Teflon-coated steel), automatic levels, tripods, level rods, and digital theodolites. Also included are eight standard grade total stations and three high precision total stations with the required prisms for high-resolution, accurate measurements of distances and angles. The lab also houses eight surveying quality global positioning systems and associated peripherals. The equipment is sufficient for the surveying component of the course. The lab has the following equipment:

- 9 engineering grade Autolevels
- 7 surveying grade digital theodolites Eight surveying grade total stations
- 2 surveying grade GPS units

- 10 mapping grade autonomous GPS units with external antenna
- 3D Laser Scanner

Undergraduate Geotechnical Engineering Teaching Laboratory (21 Lowry Hall)

Room 21 Lowry Hall is used primarily for teaching undergraduate students enrolled in the Introduction to Geotechnical Engineering Laboratory (CE 3211). When not used by CE 3211 students, 21 Lowry is sometimes used by undergraduate students enrolled in Creative Inquiry courses, and undergraduate and graduate students working on research projects. Included in 21 Lowry is equipment for conducting Atterberg limit, soil classification, in-place density, permeability, compaction, consolidation, unconfined compression, direct shear and triaxial compression tests. Laptop computers control loadings and record sensor measurements made by the GEOTAC consolidation, unconfined compression, direct shear and triaxial compression testing systems. Four 3-position pressure panels are available to support triaxial and permeability testing. Other equipment in 21 Lowry includes four digital balances, two drying ovens, and one Shimpo pug mill for fabricating test specimens of clay. Each CE 3211 class section is typically organized into four groups of 3 to 4 students. Four sets of equipment are available for students to conduct the Atterberg limit, soil classification, in-place density, permeability and compaction tests. Two sets of equipment are currently configured for conducting the consolidation, unconfined compression, direct shear and triaxial tests. An additional two sets of equipment for consolidation and triaxial testing are needed so that each of the four groups of students can conduct their own tests. Additional clean space is requested in the space allocation plan for the proposed building renovation to store, service and prepare the computer-controlled equipment used in the consolidation, direct shear, unconfined compression, and triaxial tests.

Construction Materials Lab (Room 23 Lowry Hall)

The Construction Materials laboratory is used for preparation, testing and analysis of construction materials, including aggregates, cement, concrete and asphalt. There are four student work areas in the laboratory. Improvements have been made to the concrete mixing area and waste water collection area. The curing room plumbing system has been upgraded and new tables have been purchased for mortar testing. A dust control system has been added to the sieve room. The existing equipment in this laboratory is adequate for the program requirements and it has been appropriately maintained. In addition, new equipment has been added to the laboratory to enhance the quality of understanding of the material as well as to reduce the wait-time for students in conducting their experiments. Asphalt-related materials testing is conducted at the asphalt facility, located off-campus. Available equipment is as follows:

- 2 Test Mark compression test machines (300 and 500 kip)
- 4 Hobart mixers
- 4 digital balance scales

- 2 drum type concrete mixers Shaker table (vibratory)
- Wet room for curing concrete
- Three Rotap sieve shakers
- Gilson sieve shaker
- Forney LA abrasion machine
- Wet concrete saw
- Bico rock crusher
- Bico pulverizer
- Despatch oven (large)
- Many miscellaneous sieves and concrete molds.

Fluid Mechanics Laboratory (Room 30 Lowry Hall)

The Fluid Mechanics Laboratory is used for CE 3410 Introduction to Fluid Mechanics and is located in Room 30 Lowry Hall. Housed in the Fluid Mechanics lab are four portable experimental workbenches and equipment for a variety of larger experiments. Each workbench includes a small sump, a pump, and a variety of accessories enabling students to study several topics including hydrostatic pressure and the use of manometers. A mobile flume is used to study open channel flow phenomena and structures, such as hydraulic jumps and the effect of obstructions on open channel flow. Head losses in pipes are studied using a long pipe with numerous pressure taps connected to a manometer. This set up has been upgraded with new pipes, manometers, a pump and a sump. The lab also includes an acoustic three-dimensional velocity meter to allow accurate, high-resolution (both in time and space) velocity measurements. Two additional workbenches are fitted with pumping equipment to investigate pumps in series and parallel, study relationships between head and flow, and pump system curves. The lab is also used for research. A 36 foot by 4 foot by 2 foot recirculating flume has been constructed for research projects. The existing equipment in this laboratory is adequate for the program requirements and it has been appropriately maintained.

- 4 Tecquipment Flow Benches
- 4 Gunt Hydrostatic Pressure Experiment Stations
- 4 Tecquipment Flow Tube Experiment Stations
- 4 Omega Digital Flowmeters
- 28 foot long brass flow tube experiment with digital and “U” manometers
- 2 Tilting Flumes with accessories

Capstone Design Laboratory (300 Lowry Hall)

The Capstone Design lab, a smart classroom, is located in 300 Lowry Hall and has nine computers, two 8 ½ x 11 printers, one 11 x 17 printer, and a smart classroom overhead projection system.

Geomatics Laboratory (Room 311 Lowry Hall)

The Geomatics Laboratory is located in Room 311 Lowry Hall, and is equipped with 17 computers (including a teaching machine) and peripheral equipment. The Geomatics laboratory is used for the computer portion of CE 2550 Geomatics, and when not used by the CE 2550 classes, it is used as a laboratory for some graduate classes. The lab also provides part-time use for software components of several other classes including CE 4590 Capstone Design Project. The tables in this lab are custom-built and include large table tops and monitors mounted on swing arms. The computers have a full range of spatial analysis and modeling software, including Maptitude GIS and AutoDesk's Civil 3D and Land Development Desktop that works with AutoCAD to perform site design. The lab has a large-format plotter, a large digitizing tablet, and several smaller tablets. The equipment in the laboratory is current and is appropriate for the course content.

- 17 computers with specialized software for surveying, GIS, and land development
- One laser printers Large format printer
- Smart classroom setup with digital projection system Large 36"x48" digitizing tablet
- Seventeen 11" x 17" tablets
- Eight Large custom-built tables

Roadway Design Laboratory (315 Lowry Hall)

The Roadway Design Laboratory located in 315 Lowry Hall has the following equipment.

- 6 computers with specialized software
- Large format printer
- Laser printer
- Wide format printer
- Six large custom built tables

When not used in that regard, it serves as a laboratory for some graduate classes, undergraduate CI courses and as overflow for the CE capstone design course. Custom built tables have a full range of spatial analysis and modeling software include Maptitude GIS and AutoDesk's Civil 3D and Land Development Desktop for performing plan profile, earthwork and drainage calculations with road design projects. The lab has a large-format

plotter, large format ink-jet printer, and laser printer. Additional equipment includes tools, materials and supplies for hand drawing instructions (e.g. curve sticks, planimeter, triangles, scales).

RESEARCH LABS/Lowry Hall

Corrosion Research Laboratory (CorRLab) 17 Lowry Hall 222 Office (Faculty)

Directed by Dr. Amir Poursaee, the CorRLab is engaged in research to develop new and innovative technologies to study and mitigate damage due to corrosion. This unique multidisciplinary research environment addresses the synergy between corrosion, materials science, and structural damage. In addition, underway is the creation of various evaluation and damage detection techniques including different corrosion measurement methods and crack detection systems. Information obtained from different projects in this laboratory is used to model the behavior of metallic materials subjected to aggressive environments. CorRLab trains students on the undergraduate, masters, PhD, and post-doctoral levels and collaborates with researchers from different department institutes to extend their research. The mission of the CorRLab is to explore potential solutions to enhance durability and, ultimately, sustainability of metallic materials for future.

The CoRLab has the following equipment:

- Princeton Applied Research PARSTAT 2273 Potentiostat
- Bio-Logic SP-200 Potentiostat
- Gamry Interface 1000, Potentiostat
- Gamry ParaCell Electrochemical Cell Kit
- Keithley Model 2750 Digital Multimeter, Data Acquisition, Switching and DataloggingSystem
- Keithley Model 7708 40-Channel, Differential Multiplexer Module
- Bio-logic SECM370 - Scanning Electrochemical Microscope System
- Automatic Electrical Monitoring System (AEMS)
- Automatic Corrosion Monitoring Program (ACMP)
- Reference electrodes
- Keithley Model 6221 AC and DC Current Source
- PINE AFCT2 Coefficient of Thermal Expansion of Concrete Measurement System

Chen's Computational Geomechanics Lab 133 Lowry Hall

Dr. Chen's lab is conducting research activities related to the following topics

- Machine learning-enable and image-based characterization of geomaterials
- Characterization and modeling of biomass particles for renewable bioenergy applications
- Martian and lunar regolith simulants for NASA's in-situ resource utilization

- Regional liquefaction hazard assessment and mapping
- Performance-based liquefaction hazard assessment and loss estimation

Rangaraju Concrete Research Lab

Construction Materials Lab (Room 23, 23A, 25 and 29 Lowry Hall)

The Construction Materials Teaching and Research Laboratories are located in Rooms 21A, 23, 25 and 29 of Lowry Hall. The equipment in these rooms is primarily used in sampling, preparation, testing and analysis of construction materials, including aggregates, portland cement and concrete. Lowry Rm. 21A houses equipment to conduct sieve analysis, aggregate crushing and pulverizing operations as well as LA Abrasion test and a large aggregate-drying oven. A dust control system has been added to this room to control the dust produced during the sieving operations. Lowry Rm 23 is primarily used as the undergraduate teaching lab space, wherein four large student workstations are housed. These workstations are equipped with electrical outlets to power weighing balances and mortar mixers along with providing a work space for students. Underneath each workstation, the cabinets provide space for storing lab accessories. In addition, this room has a dedicated space for concrete mixing operations, wherein a Lancaster Pan mixer is located. This mixing area is also equipped with floor drains to capture the wash water from the concrete mixing operations and drain it into an external storage tank, which is periodically emptied out by EHS. Lowry Rm 23 also houses a curing room, wherein a sprinkler system keeps the relative humidity in the room at 100% all the time to help with curing concrete test specimens. This room also contains 3 stainless steel cabinets wherein some of the equipment (such as Pressure meters, slump cones, sample molds, etc.) used in the lab activities is stored. The existing equipment in this laboratory is adequate for the program requirements, however it needs to be appropriately maintained and calibrated on a yearly basis. Asphalt-related materials testing is conducted at the asphalt facility, located off-campus.

Lowry Rm. 25 is mixed use space to serve both teaching and research needs. Room 25 houses Shimadzu 50 Kip Universal Testing Machine which is used in laboratory testing of specimens in Springer II course. In addition, this space also houses several other pieces of equipment such as Adiabatic Calorimeter, Autoclave Testing machine and others that are routinely used in research related to concrete materials. Lowry Rm. 25 also has computer workstations which are used by graduate students.

Lowry Rm. 29 is exclusively used for activities related to research on concrete materials. In addition, Lowry Rm. 29 is used to store the raw materials, molds, test specimens, and other chemical supplies needed to conduct concrete research.

Available equipment in Rooms 23A is as follow:

- Forney LA abrasion machine
- Wet concrete saw
- Badger rock crusher
- Bico pulverizer
- Despatch oven (large)
- Gilson Sieve Shaker
- RoTap Sieve Shakers (3)
- LA Abrasion Machine
- Gilson Tray Sieves

Available equipment in Room 23 is as follows:

- 2 Test Mark compression test machines (300 and 500 kip)
- 4 Humboldt mortar mixers
- 4 digital balances
- 2 vibratory shaker tables for consolidation of concrete
- Wet room for curing concrete
- 3 Stainless Steel Cabinets for Storage
- Lancaster Pan Mixer for Concrete

Available equipment in Room 25 is as follows:

- Shimadzu 50 Kip Universal Testing Machine
- Boeken Autoclave Testing Machine
- Humboldt Adiabatic Calorimeter
- TECA Cold Plate
- 1 digital balance
- Precision Match-Cure System for Concrete
- RLC Rapid Chloride Ion Permeability Testing Equipment
- Miscellaneous items

Available equipment in Room 29 is as follows:

- 60 degrees Celsius walk-in hot chamber
- 38 degrees Celsius walk-in chamber
- 4 Despatch Ovens
- 2 Freezers
- Logan Freeze-Thaw Testing Unit
- Hot Water Bath
- Masonry Saw Machine
- Allied High Tech Slow Speed Diamond Saw
- 2 Polishing Wheels
- Miscellaneous items

Asphalt Rubber Technology Service

The Asphalt Rubber Technology Service (ARTS) near the main Clemson University campus has a state-of-the-art laboratory for conducting research and testing in asphalt technology, specifically as relates to aggregate characterization, asphalt mix design, asphalt mix performance testing, asphalt binder physical characterization, and asphalt binder chemical characterization. The Laboratory is equipped with the following state-of-the-art equipment for a broad range of asphalt testing:

- 2 Troxler gyratory compactors Two rotational viscometers
- 2 Pine test presses Six ovens
- 3 digital balance scales

Wind Load Test Facility

Kaye Group Wind Load Test Facility (WLTF)

The Wind Load Test Facility is a large scale boundary layer wind tunnel used for modeling wind effects on structures and other environmental flows. It has been used for measuring loads on low-rise buildings, pedestrian level wind studies of inner city developments, and the path of embers in model wildfires. It has an 8' by 10' test section and is equipped with:

Two 100 hp motors spinning 6' diameter propellers

200 horsepower VFD to control fan speed

6' diameter turntable for changing the wind direction over model structures

256 high frequency pressure transducers for measuring pressure distributions over structural surfaces

6 DOF load cell

2 cobra probes for measuring all three components of velocity in the flow
Instrument traverse for mounting and moving instruments in wind tunnel

The primary goal of this lab is to improve understanding of the role of fluid mechanics in a broad range of natural and man-made hazards to enable effective and efficient hazard mitigation. We are doing novel work in an experimental and modeling study to improve understanding the mechanics of ember flight in wildfires and quantify the risk of spot fire generation ahead of the main fire front. This work follows on from prior research into windborne debris flight during severe wind storms. The research team also works on more classic problems in environmental fluid mechanics including the mechanics of turbulent plumes and the dispersion of dense gasses in urban areas.

Built Environment Lab (BEL):

The Structural Engineering test facility supports experimental research related to the performance of buildings, bridges and other structures. The lab has an indoor test area with 6000 ft² of floor space for testing of full-scale building or bridge components and includes a 2000 ft² reaction floor, and high capacity load frames. In addition, the lab serves as the home base for wireless/mobile instrumentation of highway bridges. The lab is equipped with closed loop hydraulic and screw-drive actuators for applying loads, an air cannon for missile impact studies, a universal test machine or testing small components and data acquisition equipment to measure and record data (stresses, loads, accelerations and deformations).

Madathil Group-Human-Systems Integration Laboratory

The Human-Systems Integration Laboratory (HSIL) is housed in 321 Fluor Daniel Hall. The mission of HSIL is to pursue cutting-edge research in human-machine systems. The goal is to enable people to use automation to carry out their activities productively. The laboratory applies user-centered design methodologies to develop and refine human-computer systems for a variety of applications within the construction, production, and service sectors, including information and knowledge management, collaborative design, quality and process improvement, and education and training. The HSIL involves both undergraduate and graduate students in its research and development activities. The laboratory supports individual and group design activities, including concept ideation, iterative design and system development. The laboratory maintains 5 desktop personal computers with 19-inch LCD monitors. The lab has a Tobii X60 eye tracking system. Tobii X60 eye tracker allows for large head movements, providing a distraction-free test environment that ensures natural behavior. The lab has access to two HTC Vive head mounted displays (HMDs), and Microsoft HoloLens for experimenting with augmented reality. In addition, the lab also has access to the Ladybug, which records 360° videos similar to Google Street View.

Other Resources

The Department of Civil Engineering has two full time technicians with computer, electronic instrumentation, machine tool and design expertise and project management skills. The technicians are available to work on projects, and are responsible for building and maintaining physical models and equipment. Their expertise will be utilized in the design and fabrication of various fixtures.

Machine Shop (Room 140 Lowry Hall)

- Large 9 x 48 milling machine
- Three lathes various sizes
- Two bandsaws (one vertical, one horizontal)
- Table saw
- Belt/disc sander
- Media blasting cabinet
- Lincoln MIG welder
- Miscellaneous hand tools