Applied Research & Technology Program NEWSLETTER

Program of Distinction
Ogden College of
Science and Engineering

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A Program of Distinction

Western Kentucky University

Ogden College of Science and Engineering
Applied Research and Technology Program

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Feature Center: Hoffman Environmental Research Institute

The Hoffman Environmental Research Institute is a consortium of scientists and students dedicated to research and higher education at the frontiers of environmental science. Its primary mission is to be a leader in the development of innovative, basic, and applied research programs aimed at understanding the dynamics of human-landscape-atmosphere interactions. A major goal of the Institute's activities is to actively involve undergraduate and graduate students in all aspects of this research as an integrated part of their academic programs. The purpose is to nurture their intellectual growth, critical thinking skills, and technical experience in the environmental discipline.

Dr. Chris Groves is director of the Hoffman Environmental Research Institute. He received a Ph.D. in Environmental Sciences at the University of Virginia in 1993 where he designed mathematical models to study karst aquifer evolution. Since then, with his students and NPS hydrologist Joe Meiman, he has developed an active research program in and around Kentucky's Mammoth Cave System, most recently concentrating on problems associated with karst landscape evolution, landscape/atmosphere CO_2 interactions, and drinking water source quality. He is also working on a variety of hydrogeology and environmental research efforts in the karst areas of southwest China, and is an active member of the China Environmental Forum at the Woodrow Wilson International Center for Scholars in Washington D.C. Chris currently co-directs (with Yuan Daoxian and Giuseppe Messana) the United Nations scientific program, IGCP 448 *World Correlation of Karst Geology and Relevant Ecosystems,* and serves on the national Board of Directors of the Cave Research Foundation. In September, he will travel with a Hoffman Institute group to Hanoi, Vietnam and present an invited keynote address entitled *Recent United Nations Efforts for the Global Study and Protection of Karst Resources* at the "International Transdisciplinary Conference on Development and Conservation of Karst Regions."

For more information about Hoffman Institute or Dr. Groves go to http://hoffman.wku.edu

Materials Characterization Center
Combustion Laboratory

Mercury is a toxic, persistent pollutant that accumulates in the food chain. Fossil fuel-fired utilities are the largest source of human-generated mercury emissions in the United States. The U. S. Environmental Protection Agency (EPA) announced its regulations on mercury emission standards in accordance with the Clean Air Act on December 15, 2003 and required compliance from the power industry. The regulations required the power industry to implement the maximum achievable control technology to reduce mercury emission 30% by 2010 and 70% by 2018. The Combustion Laboratory at Western Kentucky University (WKU) is one of five laboratories in the nation capable of performing mercury sampling, measurement testing, and analysis. Specifically, the Combustion Laboratory operates a unique facility. The Mobile Mercury Monitoring Laboratory contains numerous analytical instruments to provide real-time, on-site, and validated information quantifying mercury emission correlated to power plants' operating parameters.

In order to comply with the EPA mercury emission standard, it is critical for the power industry to determine the emitted amount of mercury within the existing control devices. Such analysis is not an easy task. Imagine the emission environment as the Houston Astrodome filled with 30 billion ping-pong balls with only 30 balls as the mercury content. To correctly determine this mercury content, the WKU Combustion Lab must always invest in the latest technology. Consequently, nineteen power companies with 29 different generating units have contacted the WKU Combustion Lab for help since 1999.

Furthermore, the laboratory staff has been strictly instructed to come up with operation and QA/QC procedures consistent with the EPA specification and conduct field tests according to these. Specifically, the data collected from the CEMS has been validated with the American Society of Testing and Materials (ASTM) Method D6784-02, commonly known as Ontario Hydro Method (OHM). All the effort devoted is to provide the customers with the most valid data.

The Combustion Laboratory at WKU has built up an industry-wide reputation due to its highly trained personnel, most up-to-date instrumental and operational specifications reflecting the EPA requirements, and the desire for efficiency, accuracy, and honor. In 2004, the WKU Combustion Laboratory is anticipating substantially increased funding, for example, the "Large Scale Mercury Control Technology Field Testing Program" funded by the Department of Energy. Based on increased awareness of environmental quality issues, as well as advancing measurements and control technologies implemented by the WKU Combustion Laboratory, it is expected to be another successful year for the Combustion Laboratory in 2004.

-submitted by Wei-Ping Pan, Ph.D.
Materials Characterization Center
Combustion Laboratory

The Materials Characterization Center Announces Two New Laboratory Facilities

The Materials Characterization Center is pleased to announce the renovation and construction of two new laboratory facilities, totaling over 38,000 square feet to be located in the former Bowling Green Mall on Nashville Road. Advanced combustion and emission control technology will be demonstrated in a 13,500 square foot Combustion Laboratory that includes fuel preparation and analysis equipment, as well as the newest circulating fluidized bed combustion systems (CFBC). The expected completion date for the renovation is the summer of 2004 and the expected completion of the construction of the CFBC system is the summer of 2005.

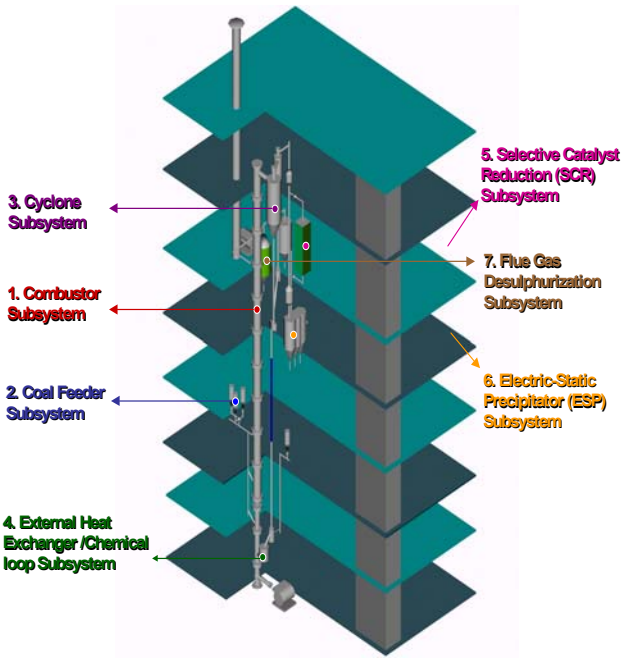
Dr. Wei-Ping Pan, Dr. Kunlei Liu and Dr. John T. Riley at Western Kentucky University (WKU) have been awarded a two million dollar grant from the U.S. Department of Energy for their project "Establishment of an Environmental Control Technology Laboratory with a Circulating Fluidized Bed Combustion System." The grant award was made through the Combustion Technology University Alliance (CTUA), a program at the National Energy Technology Laboratory in Pittsburgh. Approximately 20 universities (almost all PhD granting institutions) and 15 companies make up CTUA. This applied research program was started to help coal-fired power plants deal with current problems of operation and help develop strategies to meet environmental requirements. Senator Mitch McConnell was instrumental in getting Congress to appropriate the funds to establish the CTUA.

The primary objective of this project is to establish an Environmental Control Technology Laboratory (ECTL) using a multifunctional circulating fluidized bed combustion (CFBC) system. The system can be easily configured to make combustion runs with various fuels under varying conditions to analyze and monitor air pollutant emissions, as requested by the lab's industrial partners. The ECTL will help develop technologies that can be used to control emissions under multi-pollutant control legislation that is under consideration by Congress. The successful development of these technologies will provide scientific data on atmospheric pollutants resulting from combustion systems and the methodologies required to reduce the emission of these pollutants across the United States. This grant award comes as a result of cooperative efforts between the Department of Chemistry and the Department of Architecture & Manufacturing Science through the Materials Characterization Center and the Applied Research and Technology Program. Chemistry students will help run the combustion system and perform chemical analysis on the fuels and combustion residues. Students from Architecture and Manufacturing Science will help design the CFBC system and the facility to house it.

Hand in hand with the Combustion Laboratory will be the construction of a substantially expanded Materials Characterization Center (Coal and Fuel Laboratory, Thermal Analysis Laboratory, and Trace Organic Laboratory). The new facility will increase the capability of services offered to many regional and national industries that require fast, accurate analysis for manufacturing, quality control, and public health purposes.

Students, staff, faculty, and visiting scholars from many countries will continue to staff these most advanced laboratories, utilizing sophisticated and cutting-edge instrumentation that in turn provides the most relevant training experience. In addition to well-established instrumentation such as GC/TOF-MS/Thermax, XRD with high-temperature stage, and Micro-Thermal Analyzer, expanded state-of-art thermal analysis techniques and applications of nanotechnology will be employed.

-submitted by Dr. Wei-Ping Pan
Materials Characterization Center
Combustion Laboratory



Electrical Engineering

WKU's "Runaway Bulldozer"

WKU- Engineering Dept.
Hosts Robot Competition on November 8th, 2003

Last November the Department of Engineering sponsored the 4th annual robot competition. The competition motivates students by challenging them to build a remotely controlled robot that accomplishes a defined task within a competitive setting. Using only the materials provided, students have eight weeks to design, develop, and test a robot that can outperform their competitors. During this time, the students experience the same problems, challenges, and breakthroughs that an engineering team encounters when it takes a product to market. There are team dynamics, time constraints, material constraints, and pressure from other teams who are trying to solve the same problem.

Teams met in September for a kickoff day where the rules were revealed, and the teams were given the components for their robots. These components included a variety of electronics such as R/C controllers, motors and batteries and also building materials such as wood, PVC and aluminum. The teams were instructed to construct their robot from the provided materials.

In November, nine high school teams and one middle school team from across South Central Kentucky met for competition. The theme of the game was "Building Our Future," and the teams had to simulate building the new Engineering and Biological Sciences building. Teams had to gather building material with their robot and move the material to their building site while avoiding the "runaway" bulldozer! Points were awarded based on the number of building pieces used, type of material used, and height of the structure. In the past, the games have included saving artifacts from a fire in the Smithsonian, crossing a rotating time warp, and creating an inverted robot to stop a nuclear meltdown.

This annual high school robot competition is a successful means for promoting engineering to high school students. Last year, fourteen teams composed of approximately 150 students from south central Kentucky and Tennessee began the competition in September. Ten teams built robots and actually competed in the event. This fall a maximum of sixteen teams will be recruited to participate.

In addition to this competition, the Department of Engineering also sponsors a LEGO robot competition on the same game day. This competition is for children in grades 5-8. The students build miniature robots from LEGO Mindstorm kits. The 2004 competition was the second LEGO competition. In this competition, the students had to build a robot that could travel to Mammoth Cave (via interstate or highway) and then travel through the cave. In last year's game, the LEGO robots had to search the WKU campus for parking spaces while avoiding cars and pedestrians. Fourteen elementary and middle school teams competed in the competition this year.

The annual robot competitions are a successful means for promoting engineering to pre-college students. This event complements the project-based education focus of the new engineering programs by providing the students with a chance to solve a real-world engineering problem.

-written by Stacy Wilson, Director
Electrical Engineering Services Center

1st Place Winner: The Pink Ladies

Hoffman Institute Initiates New Karst Water Work in China

Chris and Deana Groves returned to Western Kentucky University in January from a research visit to a remote area of Hunan province in southwest China, where they laid the groundwork for assisting Chinese scientists in a new karst water resource development project.

Along with karst hydrologists from the Chinese Academy of Geological Sciences and the Xiangxi State (Hunan) Hydrogeology Bureau, they investigated several huge caves and underground rivers on western Hunan's Guizhou Plateau and negotiated details for a WKU-led cave expedition to the area this March.

The project, which entails building a large in-cave dam along an underground river, will attempt to raise water levels in the cave system almost 600 feet to make water more accessible to poor and dry communities that lie on the high plateau above the cave system.

More than 100 Chinese geologists, geophysicists, and engineers are at work on the effort. The March expedition, which will include several WKU graduate students, will assist the Chinese scientists with expertise in cave exploration and survey methods, cartography, and Geographic Information Systems to support the project.

Dr. Jiang Zhongcheng of the Institute of Karst Geology in Guilin, who has made several visits to WKU and who directs the cave research aspects of the Hunan project, explained to the team that economic development is difficult if people in the area are expending a great deal of effort just to get sufficient water and if irrigation is limited.

"There are over 40,000 people in eight remote towns and rural area between them who will immediately and directly benefit from the project if it is successful," said Dr. Chris Groves, who directs WKU's Hoffman Environmental Research Institute. He and WKU students have been working on karst research in China for eight years.

The local area, which is dominated by people of the Miao minority nationality, is generally poor. In one town, the average annual salary is less than $60; and for several months during the winter dry season, residents must carry drinking water as far as two miles from the nearest cave stream or small spring.

"Even under those difficult circumstances, the people we met were friendly and very kind," Dr. Groves said. "The improvement in the quality of life there, if the project works, will be enormous."

Dr. David Keeling, Geography and Geology Department Head, who has traveled to China twice to work with the consortium, noted that research conducted by the Hoffman Institute "is critical not only to addressing sustainable social and economic development issues in China but also to helping us understand our own community's challenges."

"The department's international programs," Dr. Keeling said, "provide faculty and students the opportunity to apply geoscience techniques to myriad problems in communities around the world. First-hand experiences in China, Argentina, Mexico, England, Bosnia, and other field sites demonstrate how critical geoscience solutions to contemporary problems have become."

-article released Jan. 22, 2004 by
WKU Media Relations, Tommy Newton

Fig. 1: American and Chinese Scientists hike toward Coffin Cave near Jishou, Hunan. The name presumably refers to a water buffalo that locals said met its demise in the cave's reported 200 meter deep entrance shaft. Mapping of the cave, which is unexplored, is a key objective of the WKU-led team in late March 2004.
Fig. 2: The main river of Thunder Cave Hunan is very low during the dry season, as here in January 2004, but can have a flow of more than ten billion liters per day during the summer monsoon rainy season.
Fig. 3: Deana Groves hikes towards a spring for water sampling in a classic tower karst region of northern Guangxi Province.

Cooperative Research: The Hoffman Institute and Mammoth Cave National Park

Going back at least to 1925 when the Western Kentucky University football team helped in the unsuccessful rescue of the trapped cave explorer Floyd Collins, deep ties existed between WKU and Mammoth Cave. Since then, there have been many field trips, research projects, and the very successful Center for Cave and Karst Studies *Field Studies Program*.

An active research program between the Hoffman Institute and Mammoth Cave National Park has been underway for six years and continues to flourish and evolve. Undergraduate and graduate students have been actively involved in this work, which focuses on the details of karst hydrogeology, geochemistry, and landscape evolution in one of the world's great natural cave laboratories. Over this period, the work has resulted in eight masters' theses, 22 publications, 31 presentations at national and international conferences, and 41 presentations at regional meetings.

Active student projects currently underway in the Park include both basic and applied research investigating the behavior and evolution of karst landscapes. A new project started this spring seeks to understand the extent of contamination of the Park's waters by the herbicide atrazine, widely used in Kentucky in corn production. Although none of the chemical is applied in the Park, it is making its way there through several pathways, including rainfall, and may be impacting the Park's ecosystem health. We are also studying groundwater hydrology, cave evolution, and carbon dioxide chemistry in both underground rivers and vertical shafts at several sites off tourist trails back within the cave system, where electronic probes and computer data loggers make continuous, high resolution measurements of water flow and chemistry.

The excellent relationships between our group and NPS, along with several other groups and departments at WKU, have led to internships and work-study programs providing great student experiences. These have been especially helpful in the support of an evolving graduate program that is in its fourth year which allows federal land managers with responsibilities for karst resources to earn specially tailored master's degrees focusing on cave and karst science and management.

-submitted by Chris Groves

Recent publications resulting from the project:

Groves, C. and J. Meiman, in review, Frequency/magnitude relationships in the evolution of a karst landscape/aquifer system, submitted to Geomorphology.

Glennon, J.A. and C. Groves, 2002, An examination of perennial stream drainage patterns within the Mammoth Cave watershed. Journal of Cave and Karst Studies, vol. 64, pp. 82-91.

Meiman, J., C. Groves, and S. Herstein, 2001, In-cave dye tracing and drainage basin divides in the Mammoth Cave karst aquifer, Kentucky, U.S. Geological Survey Water-Resources Investigations Report, 01-4011, pp. 179-185.

Meiman, J. and C. Groves, 2001, Field trip guide: The Mammoth Cave karst aquifer, Geotechnical and Environmental Applications of Karst Hydrology (B.F. Beck and J.G. Herring, eds.), Lisse: Balkema Publishers, pp. 425-436.

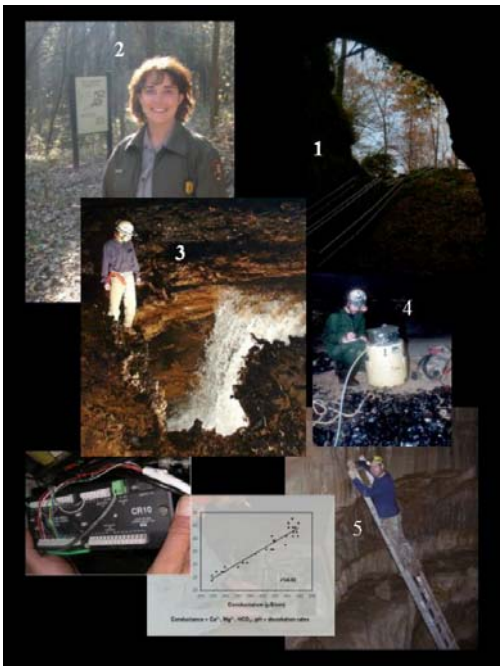


Photo Caption. *Hoffman Institute/National Park Service research at Mammoth Cave National Park: 1) Historic Entrance to Mammoth Cave, 2) Hoffman Institute graduate student Katie Seadler, manager of the Park's Water Quality Lab through the NPS Student Career Enhancement Program, 3) graduate student Joel Despain on a water sampling trip in Mammoth Cave's Logsdon River, 4) NPS Hydrologist Joe Meiman programming a water sampler in Logsdon River, and 5) graduate student Johnny Merideth installing equipment to measure cave evolution rates at Edna's Dome within Mammoth Cave.*

WKU Students win at Kentucky Academy of Science on November 6-8, 2003

BIOTECHNOLOGY CENTER

Providing Educational And Technical Services For Kentucky




Four WKU Biotechnology Center students took home prizes during the 89th annual meeting of the Kentucky Academy of Science November 6-8, 2003. The Sloan Convention Center hosted the event in Bowling Green in conjunction with the 5th annual WKU Center for Biodiversity Studies and the 10th Annual Mammoth Cave Science Conference Joint Meeting. Fledgling scientists from all over the state competed in oral seminars and poster presentations.

The meeting attracted 520 faculty and students from Kentucky with 317 research papers and posters presented.

First Place in Botany and Microbiology went to Kate Hertweck (above, upper left) of Evansville, IN for her work entitled "Does Genetic Variation Support Geographical and Morphological Patterns? A Phylogenetic Interpretation of *Mentha longifolia* (Lamiaceae) Using Molecular Data."

First Place in Cellular and Molecular Biology went to Eli Roberson (above, upper right) of Dawson Springs for his work entitled "Development of a Rapid Quantitative Real-Time PCR Method to Detect Total Environmental Fungi."

Brittany Sutherland (above, lower left) of Lawrenceburg and Nathan Woolen (above, lower right) of Beaver Dam tied for second place in botany and microbiology. Brittany's work was entitled "Origin of the *Rubus ursinus* (Rosaceae) Polyploid Complex" and Nathan's work was entitled "Phylogenetic utility of the chloroplast DNA psbA-trnH spacer in Rubus (Rosaceae)."

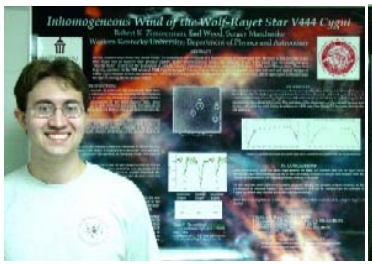
In other news, representatives from the Franklin-based biotechnology company Syngen (formerly PIC International) toured the Biotechnology Center. Syngen will share lab space to train their genetic engineering technicians in the WKU laboratories. Syngen uses molecular genetic technology to improve livestock quality in swine.

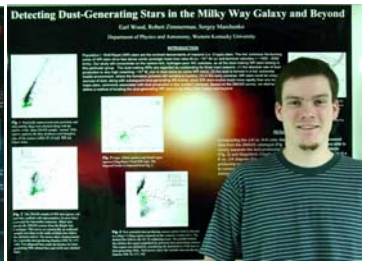
-submitted by Rick Fowler, Biotechnology Center

Western Kentucky University
Physics and Astronomy

Institute for Astrophysics and Space Science

Earl Wood and Robert Zimmerman, both majors in the Department of Physics and Astronomy, shared first place in the undergraduate oral presentation competition in Physics and Astronomy at the Annual meeting of the Kentucky Academy of Sciences held in Bowling Green, KY on November 6-8, 2003. Both students work with Dr. Sergey Marchenko. Mr. Wood presented results from his work on "Detecting Dust Generating Stars in the Milky Way and Beyond", and Mr. Zimmerman presented his results on "Clumps in the Wolf Rayet Wind of the Eclipsing Binary V444 Cygni". Each student received a cash prize of $50.00.





-submitted by Mike Carini
Director, Institute for Astrophysics

Pictured Right: Earl Wood
Pictured Left: Robert Zimmerman pictured with their winning posters.

The Center for Cave and Karst Studies

Remote Control Microgravity Robot To Be Developed by the CCKS and the EES

Over the past 16 years, the ***Center for Cave and Karst Studies*** faculty, staff, and students have performed microgravity subsurface research in order to locate cave (voids) from the ground surface for numerous government and private clients. Microgravity meters (*pictured at right*) are usually used to locate variations in subsurface rock density for petroleum exploration. However, the ***Center*** has developed a technique through which mine sites, proposed highway routes, tunnels, pipelines, hazardous spills, and sinkhole collapse and flooding sites can all be investigated. This technique can determine precise drilling locations so that monitoring wells can be installed into underlying cave streams.

The ***Center for Cave and Karst Studies*** is essentially the only one in the country performing these types of microgravity investigations. The ***Center*** was contacted by both FEMA and NASA to use microgravity to locate possible pockets or voids in the rubble at the World Trade Center site in New York so that wells could be drilled into them to look for survivors. Unfortunately, the debris piles were too uneven for our technique to be used.

As a result, The ***Center for Cave and Karst Studies*** has been awarded a grant through *The Innovation Group of the Kentucky Science and Technology Corporation* to invent and develop a remote controlled robot transport vehicle for microgravity meters. With the ***Center's*** experience and reputation in this area of study, along with the help of Dr. Stacy Wilson and staff in the ***Electrical Engineering Center***, the grant will be used in the development of a robotic transport system that will make microgravity investigations faster, less expensive, and applicable to sites where it cannot be used today. This remote controlled robot will carry the microgravity equipment across rugged terrain and have the ability to make remote measurements. Please stay tuned for future updates as this project develops!

New Schedule is released for 2004 Field Studies Courses Offered this Summer:

Western Kentucky University, through its Center for Cave and Karst Studies, and in cooperation with Mammoth Cave National Park, offers a series of one-week summer courses focusing on caves, karst, and caving. While some courses require previous subject knowledge, other courses are designed for those with merely an interest in caves. Course professors who are internationally recognized authorities in their fields, and have been chosen to lead these courses. These intense field courses combine daily lectures with field observations and excursions. Many of the courses involve rigorous trips into rarely visited portions of Mammoth Cave. The Karst Hydrology course is more surface-oriented and less physically demanding.

June 6-12, 2004
Cave and Karst Stewardship *(Carlsbad, NM)*

June 13-19, 2004
Karst Geomorphology *(Mammoth Cave, KY)*
Cave Geomicrobiology *(Mammoth Cave, KY)*
Hydrology of the Edwards Aquifer
(San Antonio, TX)

June 14-19, 2004
Karst Hydrology *(Bowling Green, KY)*

June 20-26, 2004
Cave Surveying and Cartography
(Mammoth Cave, KY)
Cave Ecology *(Mammoth Cave, KY)*

June 28-July 3, 2004
Karst Stormwater Management
(Bowling Green, KY)

-For more information contact
The Center for Cave & Karst Studies
Office Coordinator 270-745-3252
http://caveandkarst.wku.edu

The Kentucky Climate Center Develops GeoProfiles Initiative

Users of data collected at Kentucky's climate stations expect those data to provide a reliable record of Kentucky's climate. David Logan, a geography major specializing in meteorology and climatology, is working with Kentucky State Climatologist, Stuart Foster, to develop GeoProfiles for Kentucky's climate stations. GeoProfiles consist of spatial metadata documenting physical characteristics of the sites where climate stations are located across Kentucky.

A GeoProfile is created through a multi-step process. First, the precise location of a station is verified either through a site visit using a global positioning system receiver or by consulting aerial photographs and site sketches from National Weather Service climate station reports. Second, the station's location is georeferenced with respect to a digital elevation model using a geographic information system. The elevation, slope, and aspect of the climate station can then be recorded and displayed (Figure 1). Third, a digital image or set of images of the station site is added to the GeoProfile (Figure 2). The images provide visual documentation of the station's exposure. While the preferred sites for climate stations are unobstructed, grassy surfaces, a variety of exposures have been documented, including stations located adjacent to asphalt parking lots, near buildings, or under a dense canopy of trees.

Research conducted at the Kentucky Climate Center has demonstrated that significant annual and seasonal temperature variations exist between stations located only a few miles apart. The development of GeoProfiles will play an important role in better understanding our climate record.

~ Written by Stuart A. Foster,
Director, Kentucky Climate Center

Figure 1. Below Left: **Digital elevation model for Rough River Lake Climate Station.**

Figure 2. Below Right: **Rough River Lake Climate Station.**

Figure 1:

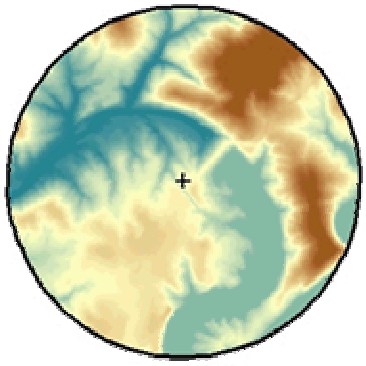


Figure 2:

The Scott Center for Construction and Engineering

The Scott Center has been involved in the construction of the Science Replacement Building since the project broke ground over a year ago.

Matthew A. Dettman, P.E., the James D. Scott Professor of Civil Engineering, has been responsible for overseeing the installation of the foundations, the quality of the concrete, the placement of compacted fill, and several other engineering services for this project. Two students, Josh Moore and Will McDonough, have also had significant involvement in the project as they have been primarily responsible for collection of material samples in the field and performing much of the laboratory work.

The first critical part of the project was the installation of the foundation system. Since the structure is being constructed in a hillside, a significant amount of soil and rock was excavated in this phase of the project. As is common in construction, the bedrock was not as it was expected to be as it contained a significant amount of soft, highly fractured shale at the elevation of the foundations. This required the foundations to be excavated about 3 feet deeper than anticipated. To ensure that the foundations were bearing on appropriate material, Dettman and his students oversaw a process that required the contractor to drill "pilot" holes into the bedrock to make sure that solid rock capable of supporting the building loads was encountered at each foundation location. Once solid bedrock was found, the highly fractured shale was excavated to the appropriate depth and the concrete foundations were poured.

The placement of the concrete was an aspect of the project that required extensive involvement from the Scott Center. Each and every time concrete was poured on this project, a representative from the Center had to be on-site to collect test samples to make sure that the concrete being placed was of the correct strength. In addition to strength, the air content of the concrete was also monitored. The purpose of monitoring air content in concrete is to make sure that not too much or too little air is contained within the concrete itself. Air is useful in concrete in that it increases its resistance to the "elements" of nature, such as freeze thaw for exposed concrete. This characteristic of the concrete must be tightly monitored because too much air can have a detrimental impact on the strength of the concrete.

In addition to the strength and air content of the concrete, the Scott Center monitored the placement of the concrete for compliance with current methods of concrete construction. A key area where the Center was involved was during the placement of concrete during very cold weather. The winter of 2002-2003 was very cold, especially during a time when concrete was being placed almost every day. Dettman and his students monitored the temperature of the concrete being delivered to the site and had to continue monitoring the temperature of the concrete in place up to 7 days after it was poured. The project specifications required that the concrete be maintained at a temperature of over 50-degrees Fahrenheit for the first 3 days and over 32 degrees Fahrenheit for the next 4 days. The critical issue here is that fresh concrete contains water and if that water freezes during the initial stages of the concrete curing process (the first 7 days) then long term strength can be reduced. One characteristic of concrete, that is very beneficial, is that during the during process it generates heat internally as the cement chemically reacts with the water to form hardened concrete. The internal temperature of concrete in the first 24 hours is often over 100 degree Fahrenheit, even if the ambient air temperature is below freezing. In order to keep that heat in, the concrete was covered with thermal blankets during the 7 day initial curing process so that it would not freeze. Fortunately, the contractor was prepared for the cold weather and was able to comply with Dettman's recommendations without slowing down the project.

(Continued from page 10)

In one case during the cold weather, a large amount of concrete was poured on a Friday and wrapped in thermal blankets to keep the heat in. Josh Moore, one of the students working on the project, was responsible for taking surface temperatures of the concrete every 12 hours during the weekend. During that weekend, high winds blew the blankets off the concrete resulting in surface temperatures of around 40 degrees Fehrenheit over the weekend. As a result, some additional testing of that concrete was performed to assure that it had achieved the desired strength. Twenty cores were taken out of the in-place concrete and tested for strength, and the results showed that there was no detrimental effect on the concrete as a result of the exposure to low temperatures. In addition, 30 non-destructive tests were performed on the in-place concrete, and these results supported the results from the cores. These non-destructive tests consisted of the rebound hammer test which is a calibrated device that measures the rebound of a steel piston after it has been impacted onto the concrete with a known force. The distance of rebound indicates the strength of the in-place concrete.

To date, almost 7000 cubic yards of concrete have been poured on this project. That's enough concrete to cover an entire football field to a depth of over 4 feet. During this process, over 700 concrete test samples have been collected and tested for quality control purposes on this project. The project is still underway and the job of the Scott Center is not done. This really is an excellent example of how ARTP provides valuable services to the community.

-written by Matthew Dettman
Director, The Scott Center
Engineering Dept.

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