Civil Engineering Redefined: Making a Foray Into the Medical Arena
Greetings from John Gulliver

It is my pleasure to communicate with you once again about activities in the department and those of the department’s alumni. The theme of this issue is devoted to civil engineering faculty crossing disciplines and applying traditional civil engineering skills to the fields of medicine and public health. They are applying their areas of expertise to solve problems through the creation of new knowledge and improved methodologies and techniques in the medical field.

Professor Tim LaPara performs teaching and research on wastewater treatment facilities, and has found bacteria that are highly resistant to antibiotics in these treatment plants. He is currently providing guidelines about releasing these bacteria into the environment. Professor Bojan Guzina has advanced non-destructive testing of soils, rocks, and pavement beyond current practice. He is also applying his expertise to the analysis of ultrasonic waves to locate malignant skin tumors, which is simply a new form of non-destructive testing. Professor Fotis Sotiropoulos works in flow through hydroturbines, river scour around structures, and the cardiovascular system. This research has been especially useful in studying the functioning of heart valve replacements. Finally, Professor Roberto Ballarini is using his expertise in concrete fracture to understand the fracture of bones, which is a material that, in a number of ways, is not unlike concrete.

This move into the medical field is a natural one for civil engineers. We have programmed ourselves to serve society, whether it is through developing and maintaining society’s infrastructure, solving difficult problems in the environment, or now helping to improve the health of individuals. It is a natural place for us to be. In fact, it was the application of civil engineering principles during the last two centuries that increased the average lifespan from 37 to 65 years. There are still too many countries where these principles have not been applied, and we are also attempting to make progress in this area.

This issue of the Civil Engineer also includes reflections of Dennis Martenson as he finished his year as national president of ASCE; a feature on long-time supporters Bob and Joyce Rosene; and a reflection on the career of Dr. Joseph Ling, who left us in February. These and other features make this one of the best magazines from a civil engineering department in the country. I hope that you will take some time and enjoy it.
**Sustainable Development Topic of Sehlin Lecture**

On November 8, Richard Wright spoke about the importance of sustainable development, a key issue for civil engineers of the 21st century. In response to this challenge the American Society of Civil Engineers and 14 other national infrastructure societies and organizations are currently developing the Practice, Education, and Research for Sustainable Infrastructure (PERSI) initiative. Wright spoke primarily about this initiative, which is designed to promote the advancement and incorporation of concepts and knowledge of sustainability into the standards and practices used throughout the life cycle of infrastructure systems.

**Scholars Walk and Wall of Discovery Include CE Faculty**

To celebrate the completion of the Scholars Walk, the University held a dedication ceremony on September 29. Civil engineering faculty Karl Smith, Heinz Stefan, Efi Foufoula-Georgiou, Ted Galambos, and Charles Fairhurst are among those honored along this walkway that recognizes great research and academic accomplishments achieved by University faculty and students.

Smith and Stefan are members of the Academy of Distinguished Teachers. Foufoula-Georgiou is a McKnight University Professor and a member of the European Academy of Sciences. Galambos and Fairhurst are members of the National Academy of Engineering.

The Scholars Walk heads west from the McNamara Alumni Center toward Northrop Mall. The walk ends 2,000 feet later at the front door of Appleby Hall on the bluff above the Mississippi River.

A panel featuring the Autoscope invention of Professor Panos Michalopoulos is included in the nearby Wall of Discovery.
Civil Engineering Redefined: Making a Foray Into the Medical Arena

Roberto Ballarini

One wouldn’t ordinarily associate the creation of new techniques in the treatment of osteoporosis, heart disease, and skin cancer with civil engineers, but when they welcome the opportunity to learn new disciplines, create new knowledge, and solve the problems of the next century—just about anything is possible. A number of our civil engineering faculty members have made a foray into the world of health and medicine. Among them is Roberto Ballarini, who arrived this fall as James L. Record Chair of Civil Engineering. While classically trained in structural engineering and solid mechanics, his natural curiosity and cross-disciplinary approach have enabled him to conduct research on advanced composites, microelectromechanical systems (MEMS), biological structures, nanoscale materials, and prosthetics. His approach to research and teaching has redefined the role of a civil engineering faculty member, and has made him a hot ticket.

Through grants from the National Institutes of Health (NIH) and the National Science Foundation’s Nanoscale Interdisciplinary Research Team (NSF-NIRT)—Ballarini is pioneering the use of MEMS devices to measure the mechanical properties of nanoscale structures. Together with Steve Eppell, a biomedical engineer and former colleague at Case Western Reserve University, Ballarini has measured the stiffness, strength, and fatigue of a single collagen fibril—the basic building block of skin, bone, cartilage, tendon, and other connective tissues. By understanding how the mechanical properties of fibrils relate to the overall properties of bone structures, they hope to develop improved and rational scientific methodologies for assessing a person’s risk of bone fracture—as in the case of osteoporosis. “Scientists have focused on the contribution of the mineral phase to bone’s mechanical properties. Much less emphasis has been placed on the role played by collagen. Clinicians currently determine a person’s risk of bone fracture using empirical correlations between bone mineral density, as measured using bone scans, and risk of fracture. While the procedure is simple, there’s no rational basis behind it. Therefore bone scans may not be truly indicative of potential fracture.”

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Clinicians currently determine a person’s risk of bone fracture using empirical correlations between bone mineral density, as measured using bone scans, and risk of fracture. While the procedure is simple, there’s no rational basis behind it. Therefore bone scans may not be truly indicative of potential fracture. It’s analogous to—can I tell if someone’s a good person by the sound of their voice,” says Ballarini.

In fact, characterizing the fracture mechanics of bone requires a cross-disciplinary approach involving structural mechanics, biology, and chemistry, and as a result Ballarini has spent time on a learning curve. In particular, he is considering bone’s growth and absorption processes. “A bone structure is not like a well-maintained building, whose properties, except for some degradation, do not significantly change over time. Bone is a living thing, and its structure is highly sensitive to the mechanical forces it experiences. In fact, after a certain age, a person’s skeleton regenerates completely every ten years or so,” says Ballarini.

Bone has a hierarchical structure that spans six distinct length scales, including mineralized collagen molecules, fibrils, lamellae, and osteons. Ballarini and Eppell are studying the behavior of
bone from the smallest constituent of bone structure, or nanoscale structure that consists of fibrils, to the bulk or macroscale structure, the bone. “We’re trying to understand how cracks initiate in the structure, how they are arrested, why they may propagate catastrophically, and what techniques we could develop to reduce the risk of fracture,” says Ballarini.

Using his tools of mechanical theories and mathematical techniques, Ballarini hopes to enable improved procedures and possibly drug therapies for measuring and reducing risk of fracture. “If it’s determined that stiffness is indeed a good indicator of fracture risk, then diagnostic tools and/or drug treatments that ensure acceptable levels of stiffness should be developed. If other characteristics prove to be more relevant—such as age-related decrease in toughness of the collagen network—then the focus should be shifted to other types of diagnostic tools and drug treatments. In fact, severe bone is damaged or when a bone breaks. This synthetic bone would temporarily become a person’s bone while the damaged bone heals and grows again. The bioinspired replacement would then be reabsorbed into the body. Synthetic materials need to be compatible mechanically with the body; they can’t be too rigid or too soft.

Having lost no time since his arrival, Ballarini is currently collaborating with professors Mrinal Bhattacharya of the bioproducts and biosystems engineering department, Tianhong Cui of the mechanical engineering department, and civil engineering professor Vaughan Voller, on the processing of synthetic mother of pearl through biomimicry, on the smallest possible scale.

“The conch shell is what got me started in this business,” says Ballarini. While at Case Western Reserve, he worked with material scientist Arthur Heuer, testing the mechanical properties of conch shells. They reverse engineered conch shells, examined their biological structures, and found that conch shells are essentially like a building and have a lot of architecture. Despite being made of 97 percent of the mineral aragonite, the conch shell, or Strombus Gigas, turned out to be the toughest ceramic composite known to man.

When comparing the structures of conch shells with bone, Ballarini found that nature uses hierarchical structural design to prevent catastrophic failure in sea shells whereas bone is very sensitive to cracks and uses healing. “You have cracks in your body continuously, but they’re usually very small and can be reabsorbed into the body. The conch shell can tolerate the presence of large cracks, but in order for bone to survive, it constantly heals itself and gets rid of all the little micro-cracks. If these cracks get too large then you have a fractured bone,” says Ballarini.

Ballarini and Eppell are also interested in developing bioinspired replacements of bone that could be used when the bone is damaged or when a bone breaks. This synthetic bone would temporarily become a person’s bone while the damaged bone heals and grows again. The bioinspired replacement would then be reabsorbed into the body. Synthetic materials need to be compatible mechanically with the body; they can’t be too rigid or too soft.

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Bojan Guzina is currently developing mathematical and computational techniques for high quality, quantitative tissue imaging using mechanical vibrations (see figure 1). These methodologies hold the promise of enabling doctors to more precisely identify cancerous lesions by focusing on the mechanical (as opposed to anatomical) characteristics of tissues, and have numerous advantages over current imaging techniques that may not be sensitive to early malignant growths. “Many forms of early cancer are difficult to discern using available imaging techniques such as the MRI, ultrasound, X-ray, and CT scan. But if one tries to uncover the mechanical properties of a tissue such as its elasticity, then those things may show up,” says Guzina.

As part of a grant proposal currently under review at the National Institutes of Health, Guzina has been working on the simulation of the mechanics of cutaneous and subcutaneous tissues. He is collaborating with electrical engineering professor Emad Ebbini, who is an expert in signal processing and ultrasound imaging (see figure 2). The quantitative ultrasound techniques they are focusing on have the potential to be used in identifying skin cancer, breast cancer, and clogged arteries.

Guzina suggests that quantitative ultrasound mitigates the factors of subjectivity and the varying expertise of physicians when they are interpreting anatomical images currently in use. For example, in the case of breast cancer testing, he says, “There may be dozens of lumps that show up in (conventional) ultrasound or magnetic resonance images of breast tissue, but the question is, which ones are ‘bad,’ and it depends upon the experience of the physician to identify cancerous tissue. You need a highly skilled physician to see which ones are potentially malignant.”

A number of cancerous tissues are often stiffer than the surrounding tissue due to, for example, an increased content of collagen fibers, according to Guzina. The key advantage of quantitative ultrasound is its ability to identify the “stiff” tissue by mathematical means whereas current methodologies rely on the subjectivity and touch of a physician’s fingers to determine the stiffness of tissue.

“If you have a ‘shallow’ cancerous tissue that can be sensed by palpation, then you may find it, but if it is deep then there is little chance of feeling it,” says Guzina. The new technique may allow physicians to probe tissue with mechanical (stress) waves—instead of using their fingers—and push not only the surface of the tissue, but also inside the tissue and measure how stiff or compliant it is. The experimental and signal processing techniques developed by Ebbini can accurately measure the displacement or axial motion of the tissue in response to the push. Using such measurements, the physician would then use the featured computational tools to assess the location, size, and mechanical properties of a lesion.

“The problem with several forms of skin cancer—that we are presently targeting—is that they may extend as far as 10 to 15 millimeters, according to the literature, beyond the visible area. So it is hard for physicians to tell visually what they have,” says Guzina. He explains that Mohs Micrographic Surgery is currently the gold standard for treating skin cancer; a technique that requires multiple excisions. This surgery entails ‘shaving’ a small part of the affected area and sending it to a laboratory for a biopsy. Physicians continue to excise the surrounding tissue and perform a biopsy, layer by layer, to make sure all the cancer is gone. A principal advantage of the quantitative ultrasound as a diagnostic tool is the ability to probe cancerous tissue and identify its extent without making any incisions. Only when the physician has (non-invasively) determined the extent of the cancerous tissue, would they make a single incision.

“If successful, we may help change the way we treat skin cancer,” says Guzina.
Due to the overuse of antibiotics and the complex genetic make-up of bacteria, a much greater number of bacteria have evolved to be resistant to antibiotics than ever before. The original solution was to develop new antibiotics faster than resistance developed. Since 1965, however, antibiotic production has nearly stopped because scientists had discovered all the antibiotics made by bacteria that they could culture. Now they have every reason to believe that as a society we’re back to square one in developing antibiotics to keep both the public and livestock healthy. Environmental engineer and Associate Professor Tim LaPara says, “The fear is that the antibiotic era is going to come to an end, and we’ll be going back to 1930 technology, which is problematic.”

LaPara has been studying bacteria and has identified resistance control and prevention of antibiotic-resistant bacteria as the solutions to the current problem. He has been working with graduate students Sara Firl, Leslie Onan, Sudeshna Ghosh, Tao Yan, and microbiology professor Michael Sadowsky—to create new paradigms for municipal wastewater treatment facilities—as part of a Center for Urban and Regional Affairs (CURA) grant. LaPara says they’ve come up with a few novel solutions to slow the proliferation of antibiotic-resistant bacteria, which makes him think they’re onto something.

Where do all the resistant bacteria come from? LaPara says it comes from people who are taking antibiotics who then shed the bacteria through defecation. He and his colleagues examined the Metropolitan Wastewater Treatment Facility in St. Paul, Minnesota and, at a quick glance it looks like they’re doing an efficient job of removing 99.99 percent of resistant bacteria per day. “But when you consider the number of resistant bacteria that is in 180 million gallons of sewage each day, the numbers are still too high. The first paradigm shift is resistance control,” says LaPara. “The civil engineering structure is there. We collect a very large portion of all resistant bacteria, and we have an entire treatment facility that has the potential to kill almost all of it. With the redesign of the treatment facility using the technology we have, we can reduce the number of bacteria that get out into the world in a very serious way.” The cost of redesigning treatment facilities is difficult to come up with, he says. He cites the current cost of antibiotic resistance, (i.e., extra medical expenses), to be somewhere between $150 million and $30 billion a year.

“The other paradigm shift is using the wastewater treatment facility to protect public health, in addition to protecting the environment,” says LaPara. Currently, wastewater treatment facilities protect public health, in addition to protecting the environment, says LaPara. Additional measures to be taken
It’s estimated that 50 million antibiotic prescriptions per year are inappropriate. There are ongoing efforts to address the overuse of antibiotics since anytime an antibiotic is used, there is a subtle or slight increase in resistance. Specifically, physicians are reducing the number of inappropriate prescriptions for antibiotics and are encouraging patients to take the complete course of their antibiotic prescriptions so that all the bacteria are killed. LaPara also recommends that the public stop using antibacterial household products.

Antibiotics are enormously popular in agriculture, accounting for approximately 70 percent of their use. They promote livestock growth (by about 5 percent) and prevent disease, which is essential especially for dense, large farms. “If one of your animals gets sick, your entire herd is at risk of dying. If you have a million herd of cattle, having them die on you is catastrophic, which makes disease prevention critical,” says LaPara.

LaPara hopes that his research slows the proliferation of antibiotic resistance, and that better wastewater treatment combined with reduced antibiotic use will extend the antibiotic era indefinitely. ◊
Fotis Sotiropoulos

For Fotis Sotiropoulos, director of the St. Anthony Falls Laboratory (SAFL), the leap into the biomedical engineering arena began in the mid-1990s when a biomedical engineering student in his computational fluid dynamics class had a question about modeling flow in heart valves. Some ten years later, Sotiropoulos has refined the question and is fully immersed in the study of how complex blood flow patterns can damage blood cells and cause heart-valve disease.

Around the same time, researchers from the biomedical community began to reach out to other engineering fields as they realized the impact advancements in computational fluid dynamics could make on the study of blood flow in the human body. “The crossing of traditional engineering boundaries was instigated by a revolutionary realization—with contributions by many, many bright people—that complex blood flow patterns somehow correlate with certain biochemical processes at the cellular level that promote disease,” says Sotiropoulos.

Sotiropoulos has been crossing disciplines for as long as he can remember. His area of expertise, fluid mechanics, allows him the flexibility to move from one area to another, which he likes. Over the years, he’s made the transition from the study of air flow in jet engines, to flow around ship hulls, to flows through a hydroturbine, to river flows, and now blood flow. “Air, water, and blood are all fluids. The mathematical equations that describe how they move are the same. So research advancements from one area can be applied to another, and it’s always fun to see the connections,” he says.

Sotiropoulos has had to learn about cellular biology and tissue mechanics for this research, which has required the expertise of people from many different fields. For example, he’s been collaborating with physicians, cellular biologists, tissue engineers, structural engineers, and a former colleague at the Georgia Institute of Technology, biomedical engineering professor Ajit Yoganathan.

“Turbulence is everywhere in engineering, but when it occurs in the human body, it usually means things are not going well,” says Sotiropoulos. The blood flow becomes very complicated with things happening across a wide range of scales. To understand what causes disease, Sotiropoulos says it’s necessary to understand the flow at the scale of blood cells, which is on the order of a few microns.

Sotiropoulos is primarily concerned with the aorta, the largest artery that originates from the left ventricle of the heart. The aortic valve, which has three leaflets, controls the flow of oxygenated blood to all parts of the body. Many things can go wrong with heart valves, and it’s critical that they function properly, says Sotiropoulos. For example, calcium deposits can occur on one side of the leaflets, which causes them to harden and not function properly. When the valves aren’t functioning, doctors either repair them or replace them by implanting a prosthetic valve.

Mechanical bileaflet valves are the most widely implanted prosthetic heart valves, accounting for about 55 percent of total heart valve implants around the world. They are very durable and last for a long time, but their downside is that they cause thrombosis, or blood clotting. Patients have to take anti-coagulant medication for the rest of their lives.”It is now widely believed that the complex blood flow patterns generated...
by the rapidly moving leaflets of the mechanical valve are responsible for damaging blood elements and causing thrombosis,” says Sotiropoulos. “The computational models we have developed have shown us for the first time exactly what these complex flow patterns look like (see figure 1). We are now ready to explore the links between blood flow patterns and blood cell damage and start thinking about how to improve existing mechanical valve designs.”

Sotiropoulos is excited about another grant proposal for the National Institutes of Health that involves the natural aortic valve. He is collaborating with colleagues from several institutions—and disciplines as far apart as cell biology and structural engineering; they are planning to deliberately disturb the blood flow patterns in a swine’s heart to observe what happens to the endothelial cells on the heart valve. This will allow them to link the precise flow conditions with the biochemical response of the cells. “The underlying question is: what type of flow patterns actually will get the cells to behave in a strange way and then become diseased?” says Sotiropoulos. He adds, “If you understand what type of flow patterns make you sick, then you can begin to ask the next question: how do I engineer a valve that actually creates flow patterns that do not make you sick? How do you re-engineer the human body?”

Computers: A Powerful Engineering Tool
Sotiropoulos’s research could not be possible without the use of a $250,000 supercomputer at SAFL. “Computational fluid dynamics has emerged in the last 25 years due to the use of computers, a powerful engineering tool,” says Sotiropoulos. The supercomputer allows he and his students to simulate in a virtual setting, or create virtual computational models of real-world processes and real-world phenomena.

Sotiropoulos and his colleagues are working to develop techniques that use MRI data to reconstruct the anatomy of the heart and blood vessels of a particular patient in a virtual world. “Being able to simulate the flow in the blood vessels of a specific patient is very significant. Surgeons can use this information to plan a surgical procedure in the computer, virtually, and decide on a course of action that’s best for this patient before the actual surgery takes place,” says Sotiropoulos. “But how reliable is the virtual world that we create?” he says. “This is a very important question because doctors will rely on the results of the simulations to make decisions, which could be a matter of life or death for their patients,” says Sotiropoulos. “That’s why in our work computer simulations must go hand in hand with in vitro and in vivo measurements to make sure that our models remain grounded to the physical reality they are designed to simulate.”

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Fig. 1. Simulated blood flow patterns through a bileaflet mechanical heart valve implanted in an actual aorta anatomy at four instants in time during the cardiac cycle (from early systole (a) to early diastole (d)). Velocity vectors and velocity contours are shown at a 2D plane through the aorta. Note the stark contrast between the smooth, laminar flow during the accelerating phase (a) and the complex, turbulent-like stage that emerges shortly after peak systole (c).
The Effect of Land Development on Trout Stream Habitat

All fish were not created equal. Trout, for example, need cold water habitat, and are sensitive to temperature change whereas bass strive in warmer water. Where bass are comfortable, trout cannot survive. The warming of lakes, rivers, and streams caused by urban land development is a threat to fish that require cold water habitat.

In Minnesota, state officials try to preserve and protect the state’s natural resources, and in this case, its trout streams. The Minnesota Pollution Control Agency (MPCA) and the Department of Natural Resources (DNR) have recently enlisted the help of Professor Heinz Stefan to develop a computer simulation program that is capable of quantifying the impact of urban land development on trout stream temperatures.

“The purpose of this tool is to facilitate the decision-making and to explore the effectiveness of mitigation measures that a developer can use,” says Stefan, who has been working with graduate students Ben Janke, Mike Weiss, and Tim Erickson; research associate Bill Herb; and associate director of applied research at SAFL, Omid Mohseni. The trout stream project is part of a larger MPCA-funded storm water project that includes other civil engineering faculty, notably professors John Gulliver and Ray Hozalski as co-PIs.

Trout Streams Defined

A trout stream has to have sustained cold water flow year-round. Even during dry periods there has to be “base flow,” which typically comes from a reservoir or groundwater. “Even if an aquifer continues to supply cold water, a trout stream can become warmer than what trout can tolerate after a rainfall,” says Stefan. “Urban development increases the potential for the warming of surface runoff. To make matters worse, groundwater in a shallow aquifer may become warmer after urban development and climate warming may have an added detrimental effect,” Stefan explains. When asked why trout are important to the state, Stefan says, “Trout are a good indicator of a healthy natural environment. They’re probably something you want to see, or at least know they exist. If the trout disappear, the feeling is, we’ve lost something.”

“The Natural Resources Research Institute on the Duluth campus has been documenting stream temperatures and flow continuously in several tributaries to Lake Superior [www.duluthstreams.org]. It’s important for the state to regulate urban development so that the natural resources are protected,” says Stefan.

The second phase of the project is to develop the computer model components. The SAFL team began with developing a surface temperature model for all kinds of ground surfaces under variable weather conditions. Herb found that paved surfaces can contribute much more heat to surface runoff than naturally vegetated areas such as a farm field or a grassy or wooded area.

Janke developed a two-dimensional runoff and heat transfer model for a parking lot. He solved equations for time variable runoff from a pavement together with equations for heat transfer processes between the ground, the water, and the atmosphere during a rainfall event. A pavement surface becomes as hot as 60 degrees C (140 degrees F) during dry weather conditions. When it rains, the stored heat warms the runoff water, and the surface runoff becomes warmer than the rainfall.

Weather data such as solar radiation, air temperature, wind speed, and dew point are input to the simulation program. “Bill Herb has made calculations for hundreds of rainfall events of the past, and we have an idea of how much heat can be delivered by a rainfall event,” says Stefan. The team is currently in the
Gerald Johnson’s
Polar Expeditions

F or the past 35 years, Gerald Johnson has been a fixed point for students navigating their way through the civil engineering program. As undergraduate director, hundreds of students have learned the fundamentals of surveying and mapping under his watchful eye.

This past summer he officially slipped into retirement and is now devoting more time to one of his favorite projects—a book on the exploration of Greenland’s northern coast, tentatively titled The Far Edge of the Earth.

Johnson knows the subject well, building a career as a navigator and cartographer on expeditions to some of the remotest spots on Earth, including Greenland, the North Pole, South America, and Baffin Island.

His first opportunity for polar navigation came in 1968 when the Arctic Institute of North America sent a team across the Greenland ice cap. The institute had a contract with the U.S. Department of Defense to set up a seismic monitoring station to track atomic tests inside the Soviet Union. They needed to find a seismic-free spot on the ice cap to set up the monitoring station. To keep the team on track, Johnson took solar observations and set out navigational flags every 500 to 600 feet along the 250-mile trek.

Johnson returned to Greenland the following summer on a mapping expedition where he helped verify the work of Arctic explorer Robert Peary. And in 1979, Johnson made a third trip to the Arctic when he joined a Canadian expedition mapping the Arctic seafloor near the Lomonosov Ridge, a submarine formation that runs beneath the North Pole ice pack from Russia to Canada.

As a result of his Arctic experiences, Johnson served as a consultant to explorer Will Steger and his 1986 dogsled expedition to the North Pole. “Nobody since Peary had reached the North Pole by dogsled,” Johnson said.

Closer to home, Johnson worked on surveying and mapping projects for the Minnesota Department of Transportation (MnDOT). He also developed the Minnesota County Coordinate System, a computational base for MnDOT surveys in the state.

process of defining “design storms,” or storms that will have the most adverse impact on stream temperatures.

The SAFL researchers are also studying other components of the urban landscape. Herb is modeling how storm sewers and storm water detention ponds affect surface runoff temperatures. He found that pond water receives additional heat from the atmosphere.

“When we understand the heat transfer and short-term hydrology of all the elements of a watershed, and when we have written heat transfer and flow equations for all these elements, we will have accomplished a great deal. The resulting model can then be applied to a particular site for hindcasting as well as forecasting under different land-use scenarios, which will be a valuable tool for the state,” says Stefan.

Trout Stream Habitat, continued from page 10

“...and has been formally recognized by the American Society of Civil Engineers through educational programs, teaching, and research.

Henryk Stolarski was named the Charles W. Britzius Distinguished Engineer by the Minnesota Federation of Engineering and Science Technologists for his long and distinguished career as an educator, researcher, and a leader in the field of civil engineering.

Vaughan Voller was awarded the Aditya Birla Chair at the Indian Institute of Science Bangalore. This past summer he spent six weeks in Bangalore where he focused on the teaching and research of models of crystal growth and geological processes.

In August, Tim LaPara and Mihai Marasteanu were promoted to associate professor, and Carol Shield was promoted to professor.

Mike Darter became the executive director of the Pavement Research Institute. He is a former faculty member at the University of Illinois and a pavement specialist. Darter is the founder of ERES Associates, a pavement consulting firm that was recently purchased by Applied Research Associates. He brings a great deal of experience, knowledge, and prestige to the Pavement Research Institute.

Randal Barnes was chosen by the undergraduate students within the Department of Civil Engineering for the 2005 Bonestroo, Rose, Anderlik & Associates Undergraduate Faculty Award for excellence in undergraduate teaching and advising.

Efi Foufoula-Georgiou has been elected as a fellow of the American Meteorological Society. She was also elected to be a member of the executive council of the Consortium of the Universities for the Advancement of Hydrologic Science.

Catherine Wolfgang French was named an Institute of Technology (IT) Distinguished Professor. This award honors exceptional faculty for their efforts in and contributions to teaching and scholarly research and for their genuine commitment to IT.

David Levinson received the Richard P. Braun/Center for Transportation Studies Chair in Transportation Engineering. This new appointment builds on the legacy started by Professor Matthew Huber and is designed to help Minnesota maintain leadership in transportation engineer-

Awards & Accolades

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Gardening for Answers

This article was previously published in the Duluth News Tribune, based on research led by professors John Gulliver and Ray Hozalski.

They’re popping up in yards, near schools and churches, even near industrial buildings across the Northland: gardens designed to capture rainwater and slow its trip to Lake Superior.

Rain gardens have been praised for years as a common-sense solution to slow stormwater runoff, keep sediments out of streams and stop fertilizers and other pollution from flowing into Lake Superior.

Sure, the flowers look nice. But do the gardens really work?

That’s what a team of University of Minnesota researchers were trying to determine Wednesday in a year-old rain garden on the campus of the University of Minnesota, Duluth (UMD).

It’s part of a statewide project, funded by the Minnesota Pollution Control Agency and Metropolitan Council, to come up with objective measurements to gauge how stormwater control efforts are working.

The study also is looking at retention ponds, underground tanks, swales and artificial wetlands to see how well they work slowing and filtering runoff, and to see how the devices should be maintained.

With many direct sources of pollution mostly under control—via municipal and industrial plants—experts say the largest source of water pollution is runoff. In cities, more blacktop and rooftops mean more water pours into streams faster, carrying dirt, grit and pollution such as phosphorus and petroleum.

A rain garden can stop the flow, collect the sediment and absorb the pollution. But only when working properly.

“We know rain gardens work. Just watch them fill up with water when it rains,” said Brooke Asleson, graduate research assistant in the project. “But how well do they work? How long will they keep working? What kind of maintenance do they need to keep them working?”

Even people who design rain gardens aren’t sure how long they’ll last. The research team has found some rain gardens in the Twin Cities that are in such poor condition, water won’t even percolate.

“We’ve seen them with the plants dead,” Asleson said, adding that some had such compacted soil the researchers couldn’t run their tests.

At UMD, the group used small amounts of water on sections of the garden, gauging how well and how fast water soaked in.

In other tests, the entire rain garden will be flooded and then monitored. Researchers hope to have the answers by November, compiling the results for public use. It may even help design better rain gardens.

Jesse Schomberg, assistant professor-extension educator for Minnesota Sea Grant’s college program, said rain gardens are new enough in the Northland that any data will help.

“The flowers look good. But they want to come up with a way to test how effective they are,” Schomberg said, adding that rain gardens are catching on in the Duluth area.

“We’re seeing little ones in people’s yards. Peace Church is doing one . . . . It doesn’t take a lot of money and they look nice. So people are figuring out how to work them into their landscaping,” Schomberg said.

The UMD rain garden along College Street was built in 2005 and is designed to hold 60,000 gallons of runoff from rooftops and parking lots on campus. If it works correctly, water pools up, cools and slowly soaks into the ground at about 1.5 inches per hour. Within 48 hours, the garden should be dry again. Grit, pollution, even bacteria from dog feces are captured in the garden.

The result is a cleaner Oregon Creek and, downstream, a cleaner Lake Superior.

UMD is required under federal and state law to have a stormwater runoff management plan, and solutions such as rain gardens help as the college adds blacktop and rooftops each year.

Left to right, civil engineering students Rebecca Nestingen and Brooke Asleson, and Tom Natwick of Valparaiso University are filling a Philip-Dunne permeameter with water. A permeameter is used to measure the saturated hydraulic conductivity of the soil.
Vanessa Storlie Hoped to Beat Guinness World Record

Although she hoped to beat the Guinness World Record by building a 60-inch sugar cube, Vanessa Storlie, an undergraduate civil engineering student, completed a 45.5-inch sugar cube tower and beat her two opponents by more than 25 inches. The competition, hosted by the Food Network, was designed to beat the Guinness Record and was held at the Mall of America on April 21, 2006. Storlie was advised by Jenn Bean, a doctoral student in civil engineering, and civil engineering professor Arturo Schultz.

This past spring and summer, Nicolas Brusselaars of Paris, France, served a three and one-half month internship in geomechanics with co-advisors Sonia Mogilevskaya and Steven Crouch. Brusselaars worked on a project concerning numerical modeling of elastic composite materials. He returned to France in August where he is attending the prestigious École Polytechnique (south of Paris), which has graduated scientists such as Henry Poincaré, Dominique François Jean Arago, Joseph Louis Gay-Lussac, and Siméon-Denis Poisson, among others.

Lisa Gordeliy, a Ph.D. candidate in geomechanics, whose research interests are in numerical modeling of the thermal properties of composite materials, has been studying with co-advisors Sonia Mogilevskaya and Steven Crouch for the past two and one-half years. In July, Gordeliy and Mogilevskaya attended the International Association for Boundary Element Methods conference in Graz, Austria. Gordeliy was a co-winner of the Young Researcher Award for the best engineering presentation at the conference. A native of Russia, Gordeliy previously studied at Moscow State University.

During the past year, members of the Earthquake Engineering Research Institute (EERI) Student Chapter have been involved in numerous outreach activities. Brian Runzel, Jennifer Baran, and Adam Lindberg gave shake table demonstrations to fourth-, sixth- and seventh-grade students at the Cesar Chavez School in St. Paul, Minnesota through the Department of Chicano Studies. Matthew Smith, Beth Brueggen, and Benton Johnson were judges at St. Paul Schools Science Fair last fall. Matthew Smith gave a structures mini-course at Patrick Henry High School in Minneapolis, Minnesota in March 2006. Beth Brueggen (adviser Taichiro Okazaki) gave a student poster presentation at the Earthquake Conference in San Francisco, California in April 2006.

Awards

Undergraduate

At the April section meeting, 12 U of M ASCE Student Chapter members were honored. Students received ASCE Student Activity Awards for their exceptional involvement in ASCE student chapter activities or ASCE Outstanding Student Awards for their outstanding academic achievement and other scholarly pursuits. ASCE Student Activity award winners were Emily Yoch, Kristina Benedict, and Lauren Glembocki. Honorable mentions were given to Krysten Saatela, Michael Berg, and Matt Hernck. ASCE Outstanding Student Award recipients were Cresten Mansfeldt, B.J. Siljenberg, and Jeffrey Kurth. Matt Beyer, Jacob Reneson, and Vanessa Storlie received an honorable mention.

Tyler Krahn received a 2005–06 Simon and Claire Benson Award for Outstanding Undergraduate Performance, for his scholastic achievements and his contributions to research. Matthew Smith received the Okerlund Award in May. He is working on his M.S. in civil engineering at the University of Minnesota. Gregory Wachman received a 2005–06 Simon and Claire Benson Award for Outstanding Undergraduate Performance, the highest student honor awarded by faculty in the civil engineering department.

Graduate

Ph.D. student Yun Huang (advisers Steven Crouch and Sonia Mogilevskaya) received a $1,000 fellowship from the National Science Foundation to attend the 7th World Congress on Computational Mechanics this past summer in Los Angeles.

Andrey Pyatigorets (advisers Steven Crouch and Sonia Mogilevskaya) took first place in his class in the Rock On 2006 climbing competition at the St. Paul Gymnasium in February (see above).

Andrew Madyarov, (adviser Bojan Guzina) a 2006 Ph.D. graduate who specialized in geomechanics, received the Cook Award in May for his accomplishments in geomechanics. He earned his B.S. and M.S. degrees in mathematics from Novosibirsk State University in Russia (Siberia). His Ph.D. thesis was titled “Fast Solutions for 3D Elastic-Wave Imaging of Piecewise-Homogeneous Bodies.” He began working as an engineer at Shell Oil Company in Houston, Texas in September.

In November 2005, R.D. Chen (adviser Tim LaFara) received an award from the Water Environment Federation’s Technical Exhibition and Conference in Washington, D.C. for his poster presentation, “Application of Membrane Aerated Membrane Coupled Bioreactor (M2BR) for the Simultaneous COD and Ammonia Removal in the Spaceship Wastewater Treatment.”

In April, Ben O’Connor was awarded the 2006 Anderson Award for his excellence in research and service to the St. Anthony Falls Laboratory.
Alumni News

Keep in touch! E-mail your news and career updates to: editor@ce.umn.edu or mail them to Civil Engineer, University of Minnesota, Department of Civil Engineering, 500 Pillsbury Drive S.E., Minneapolis, MN 55455.

2000s
Meghan Funke (BCE ’06) is working as a junior scientist in the lab of Jim Cotner, professor of aquatic ecology, in the Ecology department at the University of Minnesota. She will be applying for graduate school in ecology next fall. Above, Meghan is doing research on Lake Superior.

Joe Maurer (BCE ’06) works at Bonestroo, Roseau, Anderlik & Associates (BRA) as a EIT. He works in Apple Valley, Minnesota as an inspector for BRA’s construction services department. Joe checks construction sites, deals with contractors to make sure they meet the required specs, and manages project quantities.

Kyle Olson (BCE ’06) is currently working as a Structural EIT for SSOE, Inc. in St. Paul, Minnesota. SSOE is an AE firm based in Toledo, Ohio. His office has been involved in the design of biodiesel and ethanol plants.

Trent Riter (BCE ’06) is working towards his M.S. in civil engineering at the University and is a research assistant under the tutelage of John Gulliver. They are working on the Storm Water Management Practice Assessment Project for the Minnesota Pollution Control Agency. In May, he finished his eligibility as a member of the University of Minnesota Track and Field team as a three-time all-American.

Lori Sobolewski Houck (BCE ’06) got married and was commissioned into the Air Force within two weeks of graduation. She lives in Del Rio, Texas (Laughlin AFB) with her husband, Jack. Lori is in the Environmental Flight as a cultural and natural resources manager.

Jim Hambleton (BCE ’05) is attending graduate school at the U of M. He will receive his master’s degree at the end of the semester and begin the Ph.D. program in the spring. His research involves theoretical modeling and experimentation related to wheels operating in soils. This work stems from a Mn/DOT-sponsored investigation of test rolling, which is a procedure used on subgrades to verify the adequacy of soil compaction prior to paving.

1990s
Matt Beckman (MSCE ’96) is currently employed as a race engineer with PKV Racing, which competes in the Champ Car World Series.

1980s
Les Proper (BCE ’89) received the 2005 Minnesota Public Works Association Outstanding Director award. He served as director of public works for the City of New Brighton for 28 years before retiring last spring.

Russell H. Susag (BCE ’56, MSCE ’65, Ph.D. ’65) will receive an Outstanding Achievement Award from the University of Minnesota in recognition of his lifetime achievements in the field of civil engineering and his leadership and extensive public service to the 3M Corporation, the State of Minnesota, and the University of Minnesota.

1970s
Omer W. Blodgett (BMetE, ’41, BME ’74) will receive an Outstanding Achievement Award for his lifelong contributions to the field. In 1999, he was named by the Engineering News Record as one of the construction industry’s leaders and innovators during the last 125 years. His handbook, Design of Welded Structures, has become a standard reference textbook.

1960s
Mike Metso (BCE ’67) joined Krech Ojard & Associates of Duluth, Minnesota as the manager of their Civil Engineering Department.

1950s
Les Proper (BCE ’69) received the 2005 Minnesota Public Works Association Outstanding Director award. He served as director of public works for the City of New Brighton for 28 years before retiring last spring.

Omer W. Blodgett (BMetE, ’41, BME ’74) will receive an Outstanding Achievement Award for his lifelong contributions to the field. In 1999, he was named by the Engineering News Record as one of the construction industry’s leaders and innovators during the last 125 years. His handbook, Design of Welded Structures, has become a standard reference textbook.
MTS Professorships 2006

Roberto Ballarini earned his Ph.D. from Northwestern University. Formerly the Leonard Case Jr. Professor of Engineering at Case Western Reserve University, the department recognized his outstanding research and teaching accomplishments while here and offered him the James L. Record Chair of Civil Engineering effective this fall. His research focuses on the development and application of theoretical and experimental techniques to characterize the response of materials to mechanical, thermal, and environmental loads. He is particularly interested in formulating analytical and numerical models for characterizing fatigue and fracture of materials and structures. During his visit, he cooperated with Joe Labuz, and worked on a model of cracking in ice plates.

Fernanda Carvalho earned her Ph.D. degree from the Department of Civil Engineering at the University of Minnesota. For the past two years, she has worked as a consultant for CENPES (Research Center of Petrobras). In cooperation with Joe Labuz of the civil engineering department, Carvalho’s work involves the development and application of acoustic emission techniques to study the failure process in rocks. The main purpose is to obtain a set of tools that would allow sensor calibration parameters to be obtained in a practical and simplified way, leading to the quantitative analysis of the source parameters.

Andreas Karageorghis is a professor of mathematics at the University of Cyprus. He earned his degrees from Oxford University. Prior to his appointment in Cyprus in 1991, Karageorghis had worked at the University of Kentucky, University of Wales, and Southern Methodist University. His research interests include scientific computing and the numerical solution of partial differential equations. While here, Karageorghis gave lectures to graduate students and established cooperation with Sonia Mogilevskaya.

Radoslaw Michalowski of the University of Michigan in Ann Arbor visited the Department of Civil Engineering for two weeks in September and October. His association with the department goes back to the early 1980’s when he was a Fulbright Fellow here from 1981 to 1984. During his recent visit, Michalowski interacted with the faculty in geomechanics and other areas.

Athanasios (Tom) Scarpas is an associate professor and coordinator of the Program of Mechanics of Structural Systems at the Section of Structural Mechanics, Delft University of Technology, the Netherlands. Scarpas has developed top-notch research on applied constitutive modeling for pavement analysis and is the coeditor of the International Journal of Pavement Engineering. While here, he collaborated with Lev Khazanovich.

Visiting Professors

Bingsheng He of Nanjing University in China, visited our department from March to August 2006. He has been working with Henry Liu on transportation network equilibrium state control and has helped in the development of inverse variational inequality formulations and its solution algorithms.

Makoto Higashino, associate professor from the Oita Institute of Technology in Japan, has been a frequent visitor to the St. Anthony Falls Laboratory since he spent a sabbatical year at the laboratory in 2001–02. He visited again for three weeks in August 2006. He is interested in water quality modeling, especially solute transfer between flowing water and sediment beds, and has been working with Heinz Stefan.

Peter Weiss, (pictured at left with John Gulliver), associate professor and head of the Department of Civil Engineering at Valparaiso University in Indiana, has visited our department for the last three summers and one sabbatical year to perform research on storm water quality treatment with John Gulliver at the St. Anthony Falls Laboratory.

On Sabbatical

Bill Arnold is currently on sabbatical at the Swiss Federal Institute of Aquatic Science and Technology (EAWAG) in Dübendorf, Switzerland for the 2006–07 academic year. His research focus is the transformation of organic chemicals in aquatic systems. At EAWAG, he will collaborate with some of the world’s leading scientists in this area, notably, Rene Schwarzenbach and Thomas Hofstetter, who are using compound specific stable isotope analysis to elucidate the reaction mechanisms of organic contaminants in a variety of environmental matrices. In addition, Arnold will have the opportunity to work with Urs von Gunten, who is one of the world’s leading experts in using advanced oxidation processes to remove trace contaminants from drinking water.

David Levinson is on sabbatical at the Centre for Transport Studies at Imperial College in London, England. He is working on developing a model of the co-evolution of networks and land use, combining what is known about transport demand, and particularly induced demand, and transport investment. This extends work on network growth he has done in Minnesota, funded by the Minnesota Department of Transportation, the Institute of Transportation Studies, the Humphrey Institute, the National Science Foundation, and the Department of Civil Engineering. This work also complements an ongoing project: Access to Destinations.
Thank you to our alumni and friends!
ends for your generous support!

Mark C. & Tammy S. Magney
Hussam N. Mahmoud
Brian Malzer
Mihai Marasteanu
Laurence Margolis
Ernest Margulas
Dennis R. & Catherine M. Martenson
Glenn A. Martin
Carolyn & Anthony G. Martino
Mark K. Maves
Robert F. Mayhew
James P. McCarthy
Michael S. McGray
David M. McKenzie
Steven R. McComas
Seth T. McQuire
Thomas R. Meath
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Geraldine Wittman
Steven F. Wojtkiewicz
Patrick E. Wrase
Shimin Yang

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Dennis Martenson reflects on ASCE presidency

On a quintessential fall day, Dennis Martenson (BCE ‘67, MSCE ‘68) took the time to swing by the U and reflect on his term as national president of ASCE (the American Society of Civil Engineers). Just weeks away from giving up the reigns, he was happy to report that he’d made a start on his farewell speech in a hotel room in Detroit—characteristic of his peripatetic lifestyle as president and president-elect for the last two years. He spent $85,000 traveling on behalf of ASCE last year—meeting and greeting engineers around the country, as well as in Mexico, Ireland, the United Kingdom, France, and Canada. And, his wife, Catherine, frequently joined him.

Martenson’s affable and easy-going nature belies the fact that he held the most highly revered position in the field. With 140,000 professional members and 26,000 student members, ASCE is still growing. He’s proud of a number of accomplishments, and says, “It’s been very interesting, very rewarding, and an honor to have been elected to such a position.”

Among his presidential accomplishments is the development and implementation of the organization’s strategic plan, an ongoing and perhaps arduous process that includes both association issues and professional issues. “The process is designed to give the organization direction and focus its resources, and it won’t be a report that just sits on the shelf,” says Martenson. One of the professional issues is determining if outsourcing is a serious threat; another is the need for better trained young civil engineers entering the workforce. Last month, the National Council of Examiners for Engineering and Surveying adopted model law changes suggested by ASCE to require additional education before engineering registration.

Additional accomplishments include eight individual and 10 statements to Congress; advancement toward adoption of sustainable infrastructure methods in a consortium of 16 organizations (Practice, Education, and Research for Sustainable Infrastructure or PERSI, see Sehlin Lecture, page 3); and the completion of the External Advisory Panel peer review of the Corps of Engineers’ study on the causes of the levee failures during Hurricane Katrina in New Orleans.

Martenson has recently resumed his position as principal and senior project manager at CDM (Camp Dresser & McKee Inc.) in St. Paul, Minnesota.
In Memoriam

Joseph Ling, an environmental engineer who was known worldwide as the father of pollution prevention, died on February 22, 2006. He espoused a simple, extraordinary solution to the nation’s burgeoning pollution problems: eliminate pollutants at the source before they contaminate the environment.

Dr. Ling was born in Peking, China in 1919. He arrived at the University of Minnesota in 1948 and received the first Ph.D. degree in sanitary engineering from the Department of Civil Engineering in 1952. He returned to China and founded the National Institute of Sanitary Engineering Research before settling permanently in the United States.

In 1960, Dr. Ling joined 3M where he established and led their environmental efforts with operations in more than 60 countries until his retirement in 1984. In 1974, Dr. Ling initiated the first industrial waste minimization program in the United States, or 3M’s Pollution Prevention Pays (3P) program. The program became an international standard and served as the basis for the U.S. Pollution Prevention Act of 1990.

The influence of Dr. Ling’s work extended far beyond 3M. He served Presidents Nixon, Carter, and Bush (Sr.) in an environmental advisory role and was active in the United Nations (U.N.) efforts to globalize and expand pollution prevention. He also participated in coining the term “sustainable development” while serving on a U.N. committee with the former prime minister of Norway.

Joseph Ling received numerous awards for his innovations and service. He was elected to the National Academy of Engineering in 1976. He received the University’s Outstanding Achievement Award in 1983 and was named Engineer of the Decade by the Minnesota Society of Professional Engineers in 1989. Dr. Ling was a life fellow of the American Society of Civil Engineers and the first president of the American Institute of Pollution Prevention. He was elected to the United Nations Environmental Global 500 Honor Roll in 1990 and named one of the outstanding contributors to engineering in the past 125 years by the Engineering News-Record in 1999.

Longtime supporters of the University, Joseph Ling and his wife, Rose, have left a lasting legacy here. In 1989, they created the Rose S. and Joseph T. Ling Graduate Fellowship in Environmental Engineering. In 1999, they established the Joseph T. and Rose S. Ling Professorship in Civil Engineering to support and retain outstanding faculty in the department’s environmental engineering program.

Dr. Ling said that the environmental challenge for the next millennium is to move from pollution prevention toward sustainable development and design for the environment.

Joseph Ling once said, “Rose and I have ordered our lives according to an ancient Chinese proverb: ‘Among ten thousand ways to prepare for living, the best way is through education.’”

RECENTLY PUBLISHED

David Levinson and William Garrison recently published The Transportation Experience (Oxford University Press, 2006).

This book began as notes for classes that Garrison taught at the University of California, Berkeley where Levinson was one of his students.

A review of the book by the Institute of Transportation Studies at the University of California, Berkeley may be found at: www.its.berkeley.edu/itsreview/fall2006/transportationexperiencep1.html.

Alvin C. Schendel (BCE ’41) died on Dec. 10, 2005. After earning his bachelor’s degree in civil engineering, Schendel earned his law degree from William Mitchell College of Law in St. Paul, Minnesota. He was proud of being a member of an elite group of people who were simultaneously registered land surveyors, professional civil engineers, and practicing attorneys. He held positions as city engineer for the City of Robbinsdale, Minnesota and head of the construction department at Skyline Builders. He also worked for the Minnesota Highway Department, the Minneapolis City Water Works Department—and for engineering and land surveying firms and various railroad companies.

The “Seneca Chief,” a flotilla making the maiden voyage down the Erie Canal, c. 1825. From the collection of the Federal Highway Administration.
and Rosene Graduate Fellowship. With a recent contribution from the Rosenes, the department and the ASCE Student Chapter plan to renovate two spaces in the Civil Engineering Building, which will be named the Rosene Room for the ASCE Student Chapter and the Robert Rosene Student Lounge.

When asked to what he owes his success, Bob says, “To be involved...to be active in many professional and technical organizations, and they all add up. I received a good basic education at the University of Minnesota, and many people helped me along the way as instructors and mentors. We need to keep that in mind as we help young engineers.”

Bob is known for his energy and dedication to the activities and volunteer organizations at the University. From 1987 to 1988, he served as president of IT’s Alumni Society (ITAS). He also served on the board of ITAS from 1995 to 2002. He was chair of the committee that organized the 50th reunion of the IT Class of 1945—the Navy-V-12-NROTC War Years Reunion and the 50th anniversary of the end of World War II. Bob has been on the Executive Advisory Board of the Department of Civil Engineering since 1987.

Bob has also served as president of the Consulting Engineers Council of Minnesota, president of the Minneapolis and St. Paul Society of American Military Engineers; Minnesota’s national director for the American Consulting Engineers Council, and president of the Roseville Rotary Club. In 1993, he was named Engineer of the Year in Minnesota by the Minnesota Society of Professional Engineers. He has received other awards for service to both the Boy Scouts and his community. ◊