

# Engineering Professional

The Official Publication of the Wisconsin Society of Professional Engineers

## What Do We Know About Stray Voltage?

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July/August | Volume 1 | Number 4

# President's Corner

Dear Fellow Members,

Congratulations to Michael Lemens, PE, on a great job as 2002–2003 WSPE President. WSPE has been in poor financial condition, but this year we think we will finally be back in the black. Many tough decisions had to be made in the past year and Mike really stepped up to the plate.

Moving into the next year, we plan to maintain the same level of financial success while focusing on a few specific issues:

## Communications

Look for some improvements to our web site ([www.wspe.org](http://www.wspe.org)) that should allow us to communicate better as an organization. Each member needs to make sure they provide the state office with an accurate e-mail address. Your e-mail will not be distributed outside WSPE and we expect to provide timely, pertinent information that you will value. Our WSPE magazine, now known as *Engineering Professional*, will be distributed to many PEs who are not members of this organization. This will greatly expand our audience and create a new awareness of WSPE. Chapters are encouraged to conduct at least one function this year that invites all PEs to attend.

## Diversity

WSPE is committed to representing the viewpoints of all of our members. Currently, we do not have active participation from any women or minority members on the state level. We plan to change this in the coming year. If you are interested, make sure to contact me.

## Membership

Membership among all states in our region has fallen in the past few years. Without membership, we don't have an organization, so I will be actively pursuing recruitment. Remember, the best way to get a new member is for them to be invited by a current member. This is an assignment for each member, not just the Membership Committee. Chapter activity is important to attract new members. We will be collecting information on successful programs at our most active Chapters and distributing this information to everyone. Make a particular effort to recruit and involve younger members.

## Governor's New Product Award

The Governor's New Product Award was a successful program that was cut due to the financial limitations we faced the past few years. We plan to revive this program so we can again showcase new technologies around the state.

I look forward to working with all of you this year. We expect to continue the success that this organization has seen in the past.

Mark S. Davy, PE  
WSPE President



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# Engineering Professional

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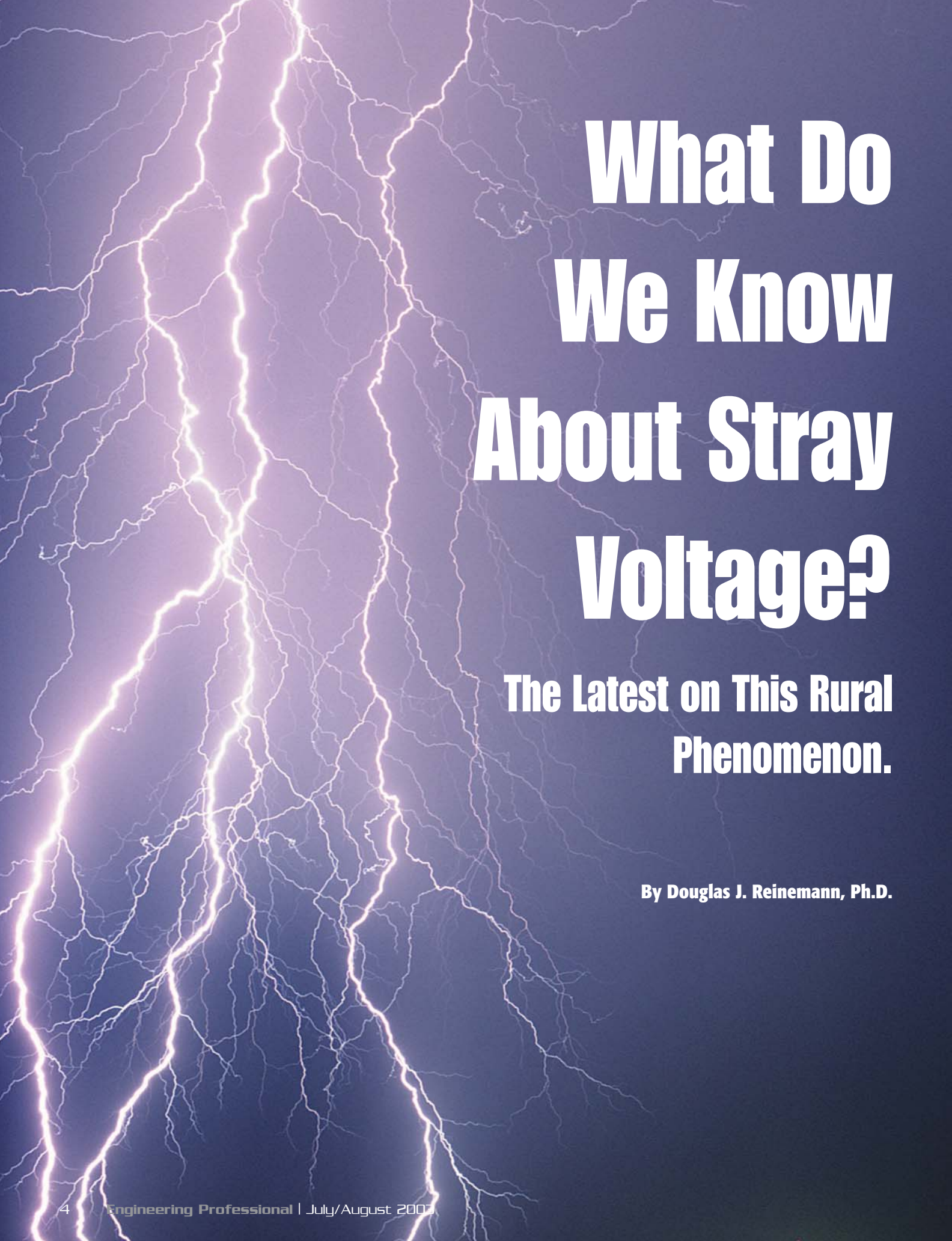
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### Writers Wanted!

In each issue, *Engineering Professional* seeks to inform and enlighten its readers about new trends and old themes of relevance to the profession. If you have an idea for an article that would interest an audience of professional engineers, contact me: Ellen Hohenfeldt, Editor, *Engineering Professional*, 7044 S. 13th Street, Oak Creek, WI 53154-1429, EngEditor@engineeringprofessional.com, (262) 781-0431. Some suggested themes:

- Professional ethics
- City planning
- Engineering education
- Legislative issues
- New engineering projects
- and certification
- Innovative technology
- Environmental issues
- Future of the profession
- Homeland security



# **What Do We Know About Stray Voltage?**

**The Latest on This Rural  
Phenomenon.**

**By Douglas J. Reinemann, Ph.D.**

The term stray voltage has been used for the past 40 years to describe a special case of voltage developed on the grounded neutral system of a farm. If this voltage reaches sufficient levels, animals coming into contact with grounded devices may receive a mild electrical shock that can cause a behavioral response. At voltage levels that are just perceptible to the animal, behaviors indicative of perception such as flinches may result with little change in normal routines. At higher levels avoidance behaviors may result.

The term stray voltage is often applied incorrectly to other electrical phenomena such as electric fields, magnetic fields and most recently electric current flowing in the earth. These phenomena are generally referred to as EMF or Electric and Magnetic Fields. The physiological interactions with these phenomena are different than the mild shock associated with stray voltage.

### Sources of stray voltage

A diagram of a typical single-phase multi-grounded Y rural distribution system is shown in Figure 1. Electric power is transmitted from a substation to the farm on the utility or 'primary' distribution system. Most rural distribution systems use a voltage of 7200 or 14,400 Volts between the primary neutral and primary phase wire. Electrical power is distributed as an alternating voltage and current with a frequency of 60 Hz (the voltage and current alternates from a positive value to a negative value 60 times per second). The 'flow' of electricity is actually back and forth in the wires, not a continuous stream as in a garden hose.

The neutral wire on the primary distribution system is grounded six times per mile or more. These grounds are provided, in part, to reduce damage caused by lightning striking the power lines. The high voltage and low current carried by distribution lines are converted to lower voltage and higher current at the farm transformer. The farm wiring system carries 240 volts on two 'hot' or phase wires and 120 volts electrical power on one 'hot' or phase wire and one neutral

wire. The neutral is also referred to as a grounded conductor (white colored insulation). The National Electric Code also requires the use of a grounding conductor (green colored insulation or bare copper) for safety reasons in agricultural buildings from the service entrance panel to the load for both 120 V and 240 V circuits.

Stray voltage is a voltage that develops on the grounded neutral system of either the farm wiring or utility distribution system. The voltage is a result of the current flow on the neutral wire and the resistance of the grounded neutral network. Stray voltage can be reduced by either reducing the resistance of the grounded neutral system or by reducing the current on the neutral wire. The most common cause of stray voltage is high resistance of the neutral wire caused by loose or corroded connections or undersized wires. Proper sizing, installation and maintenance of wiring systems is required to keep the resistance of the grounded neutral system low. Current flow on the neutral wire can be reduced by balancing 120 V loads between the phase wires, eliminating fault conditions, and using 240-volt equipment whenever possible.

### Animal research

A great deal of research on the effects of stray voltage on farm animals has been conducted over the past 40 years. The first study of stray voltage on dairy farms was published in New Zealand in 1962. In this early study a series of experiments were carried out to establish the lowest level of contact voltage at which there was a response. It was concluded that 3 volts (rms) would be a likely minimum level for response.

A summary of the effects of the most common form of stray voltage (steady 60 Hz contact voltage) on animals was published in 1991 by the US Department of Agriculture. The authors of this document reviewed the numerous studies of dairy cow reaction to voltage and current exposure and concluded that the most sensitive cows (less than three percent) begin to perceive contact voltage levels of about one volt causing one milliamp (measured as rms) of 60 Hz electrical current to flow through the cow. As the voltage and current is increased, a larger percentage of cows will perceive the current and behavioral responses will become more

FIGURE 1: TYPICAL SINGLE-PHASE MULTI-GROUNDED Y RURAL DISTRIBUTION SYSTEM

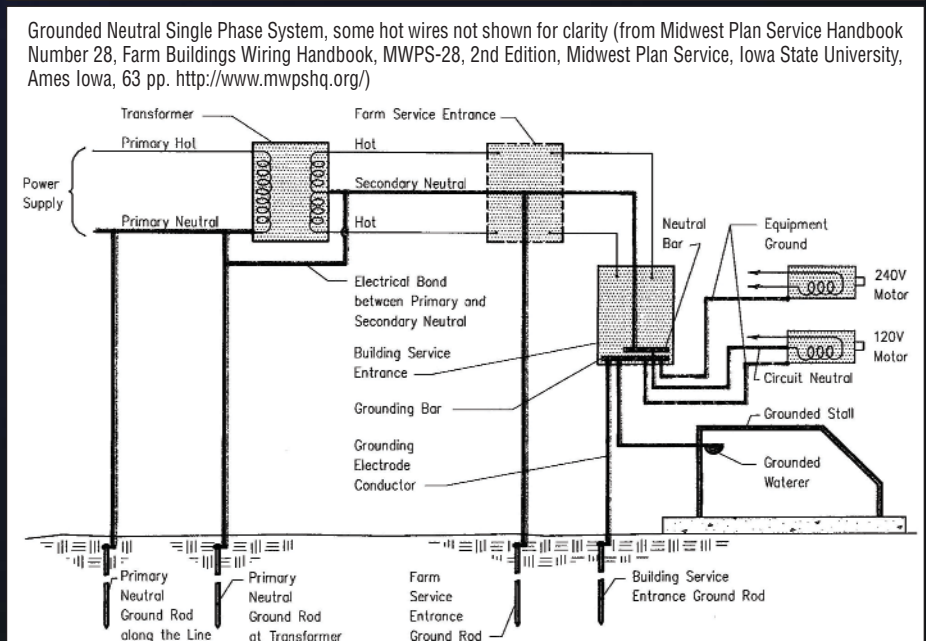
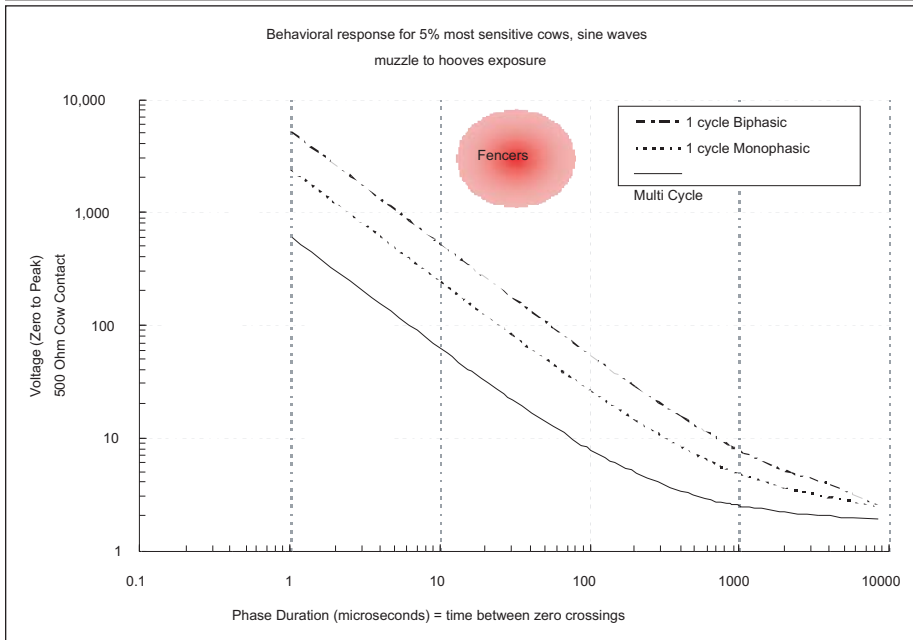


FIGURE 2: DAIRY COW BEHAVIORAL SENSITIVITY CURVES



pronounced. Numerous studies have documented avoidance behaviors in the range of three to six milliamps of current flowing through the cow. This response assumes that the cow comes into contact with objects that have different voltages and that this voltage causes sufficient current to flow through the cow. The authors recommended that cow contact voltage be kept below two to four volts (rms) to prevent adverse responses.

### Transient Voltage

More recent research has investigated the effects of high frequency or short duration transient voltages on cows. The main sources of these transient voltages on a farm are improperly installed electric fences and switching of electrical devices on that farm. The very high frequency switching transient pulses decay very quickly and do not travel far from their source. Exceptions to this are electric fences, which produce a very powerful electric impulse designed to control animals. This type of pulse is designed to produce aversion but not cause harm to the animal. Improper installation of these devices can cause these pulses to appear in unintended areas on the farm.

More voltage and current is required to perceive an electrical pulse, as the duration of the pulse gets shorter. This has been well documented on humans for over 100 years. The same has been shown to apply to cows. This knowledge has been used in the design of numerous medical devices as well as electric

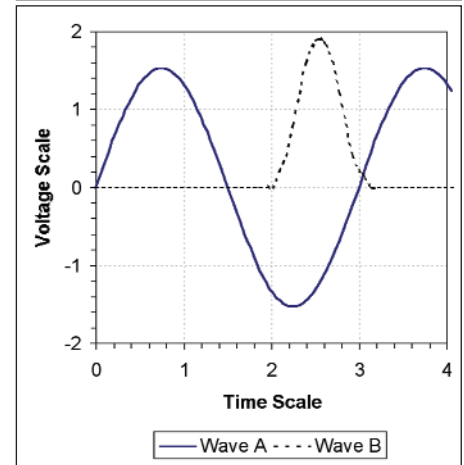
fences. The average contact voltage required for five percent of cows to show a behavioral reaction to a short duration pulse is shown in Figure 2.

A 60 Hz pulse appears on the far right of this graph. Cows are less sensitive to a single pulse than to a continuous wave. The voltage required to elicit a behavioral reaction is more than 100 times higher for a ten micro second pulse – typical of a fencer - than for an 8333-microsecond pulse (60 Hz).

The phase duration referred to here is the time for the voltage and current to go from zero to some peak positive value then back to zero. Examples of waveforms as they would appear on an oscilloscope screen are shown in Figure 3. The phase duration of wave A is 1.5 time units and the peak voltage is 1.5 voltage units. The phase duration of wave B is 1.2 time units and the peak voltage is 1.8 voltage units. The time and voltage scale settings of the oscilloscope when these recordings were made indicate the time represented by one time division and one voltage division. The phase duration and peak voltage must be measured accurately at an animal contact location in order to determine if animals could perceive these short duration electrical impulses.

The most common source of 60 Hz pulses (8333 microsecond phase duration) is starting of large electric motors. Electric fences typically produce pulses with phase duration of 10 to 100 microseconds. Switching of other electronic devices can produce pulses with phase duration of 1 to 10 microseconds or less.

FIGURE 3: EXAMPLE WAVEFORMS



### Field Studies

Controlled research has indicated that stray voltage can be problematic if sufficient voltage levels are present and cows are forced to contact this voltage. The Public Service Commission of Wisconsin has identified one volt measured across a 500-ohm resistor as a level above which action should be taken. A recent report presented the results of a field study of more than 2900 stray voltage investigations performed by Wisconsin Utilities and the Public Service Commission of Wisconsin. More than 90 percent of farms tested were below this level at the time of their first stray voltage investigation. There was no meaningful correlation between primary neutral-to-earth voltage, secondary neutral-to-earth voltage, cow contact voltage, or ground rod current and either milk production or somatic cell count. This suggests that the standards in place in Wisconsin are effective in mitigating the adverse effects of voltage and current on dairy cows.

### Ground Currents, Electric and Magnetic Fields

A recent concern has been the electric and magnetic fields caused by current flowing on the farm grounding system. Problems with utility and farm wiring can increase both the voltage on the neutral wire as well as the current flowing on the grounding system. The electric and magnetic fields produced by these currents are not perceptible to animals or humans and are much lower than normal household exposure. Electric and magnetic fields act on animals in a different way than the mild shock associated with stray voltage.

A team of experts was assembled by the state of Minnesota to review the evidence on

FIGURE 4: STRAY VOLTAGE CAN AFFECT PRODUCTION OF DAIRY COWS



Photo courtesy of USDA NRCS

the possible effects of currents flowing in the earth on the health and productivity of dairy cows. A survey of dairy producers conducted as part of the science advisors study revealed that the vast majority of dairy producers do not consider stray voltage or other forms of electrical exposure a problem on their farms. Several field studies have shown that the electric and magnetic field levels found on dairy farms are well below those shown to produce biological effects. Although the science advisors found no evidence to suggest that earth currents or the EMF produced by them were harmful, one mechanism was postulated that could produce a biological effect: current flowing through a cow producing small internal electric fields. Research conducted to examine this possibility showed no ill effect on cows exposed to these low level currents.

The science advisors gave three main findings in their report:

- ▲ *"We have not found credible scientific evidence to verify the specific claim that currents in the earth or associated electrical parameters such as voltages, magnetic fields and electric fields, are causes of poor health and milk production in dairy herds."*
- ▲ *"At the present time, there is no basis for altering the Public Utilities Commission-approved standards by which electric utilities distribute power onto or in the vicinity of individual dairy farms."*
- ▲ *"There are many well-documented non-electrical factors that are known and accepted by the scientific community, and by most farmers as well, to cause dairy cow health and production problems. Among the most noteworthy factors are poor nutrition, poor cow*

*comfort and hygiene, and low or no use of vaccinations and related preventive veterinary practices. These factors should always be addressed by those who want to improve performance of dairy herds."*

More details on the studies and surveys, as well as publications to help measure voltages on the farm, are available at the following web sites: [www.uwex.edu/uwmril](http://www.uwex.edu/uwmril) and [www.mrec.org](http://www.mrec.org)



*Douglas J. Reinemann obtained a Ph.D. in Agricultural Engineering from Cornell University in 1987. He is professor of Biological Systems Engineering at the University of Wisconsin-Madison where he has been on the faculty since 1990. He directs the University of Wisconsin Milking Research*

*and Instruction Lab ([www.uwex.edu/uwmril](http://www.uwex.edu/uwmril)) and has been involved in stray voltage research and educational programs for the past 13 years. He also Chairs the Energy Analysis and Policy Program in the UW's Institute for Environmental Studies. He received the National Food and Energy Award from the American Society of Agricultural Engineers (ASAE) in 2001, the Pound Extension Award from the UW College of Agriculture and Life Sciences in 1998, the Young Engineer Award from the Wisconsin Section of the ASAE in 1998, and was nominated as a UW Distinguished Professor in 1997. Dr. Reinemann has authored more than 30 research publications on the effects of the electrical environment on dairy cows and has organized a series of educational programs on stray voltage and farm wiring which have been attended by over 1,000 stray voltage investigators, dairy equipment installers, students and public officials.*

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# AEI's Green Building

## An Engineering Firm Designs Its New Corporate Office With the Environment in Mind

By Mike Walters, Sustainable Systems & Energy Analysis Specialist



**W**hen Affiliated Engineers, Inc. (AEI) set out to design and build their new corporate office building in Madison, the company made a deliberate decision to incorporate sustainable building concepts for no additional cost. The design team—Affiliated Engineers themselves (MEP/IT) and Flad & Associates (Architect)—designed the facility to comply with the basic certification requirements of the US Green Building Council's LEED™ rating system.

The design team initially targeted 20 different LEED™ credits for compliance, placing the building's internal environmental quality as a priority, along with resource stewardship and energy efficiency. Specific target credits included carbon dioxide monitoring, construction indoor air quality management, low-emitting materials (adhesives, paints, carpet, and composite wood), daylighting and views, construction waste management, additional commissioning, and green power.

### Project Constraints

As with any construction project, the AEI project dealt with its own specific set of constraints. First, the team needed to address the fact that the building and site would not be owned by AEI, but instead would be leased from the University of Wisconsin – Madison. Second, the team was challenged to include sustainable concepts without increasing the project's budget.

The University of Wisconsin – Madison owns a substantial research park on the west side of Madison. As such, the UW-Madison does not sell property in the park, but instead uses the facility as a long-term revenue generator. To do this

the park requires that buildings be capable of adapting to more than one tenant if necessary. Figure 1 shows the design team's solution to this requirement in which a central atrium provides the main entry for the building and a circulation corridor to other floors. The stairs on the west and east ends of the building create secondary circulation paths. In an effort to minimize the energy consumption occurring in these circulation areas, the design team focused on creating spaces that are daylit via high quality fenestration. Both the primary and secondary circulation areas are bound on three sides by low-e glass with a visible light transmittance of 19 percent and a solar transmittance of 12 percent. Additionally, the secondary circulation stairwells provide a buffer zone for building exit and entry.

With the building's massing and circulation issues resolved, the team addressed site details. The building was oriented parallel to the existing façade of the nearest structure which simultaneously integrated the new building with the park and maximized north facing surface area for daylight harvesting. Finally, to coordinate with the existing aesthetic of the research park and eliminate the need for irrigation, the landscaping plan called for natural prairie seeding augmented by native tree species adjacent to the building and throughout the parking area.

The team then turned its attention to further integrating sustainable concepts into the project while maintaining a fixed budget. Project engineers concentrated specifically on reducing the heating/cooling loads and maximizing the use of daylighting for open office areas and public spaces. Additionally construction processes were examined to ensure indoor

environmental quality, regional procurement, and waste management.

The cornerstone of the building's sustainability efforts is the facility's daylighting strategy. A concept called Cool Daylighting™, developed by the Daylighting Collaborative, is used extensively throughout the building. The Cool Daylighting™ installation uses different low-transmittance glazing apertures to afford daylighting without glare and unnecessary solar thermal gain. The AEI building uses 35 percent transmittance glazing for daylighting and 19 percent transmittance glazing for view glass. Solar transmittance for the glazing system is 24 percent and 12 percent, respectively.

While the daylighting scheme does provide exceptional natural lighting to the building's interior spaces, other benefits are also apparent. First, lighting controls facilitate a 25 percent reduction in energy consumption by artificial lighting. This reduction not only saves operational costs associated with utility fees and relamping but also saves 20,000 pounds of greenhouse gases annually. Finally, the two-type glazing system also lowered the solar thermal gain enough to downsize each of the building's two air handling units by five tons each.

Once energy conservation measures were taken into consideration the design team stressed the procurement of energy from renewable sources. With this in mind AEI decided to purchase 60 percent of the building's total electric demand from wind sources. The decision drastically reduces the building's burden on the environment and results in savings of 972,000 pounds of CO<sub>2</sub> and 257 pounds of NO<sub>x</sub> annually.

Apart from integrating the Cool Daylighting™ system with the mechanical system and building

FIGURE 1: ENTRY LEVEL FLOORPLAN



FIGURE 2: AEI BUILDING FROM SOUTHEAST



fenestration, many other efforts toward sustainability were realized. Throughout the construction phase contractors rigorously adhered to a waste management program that recycled over 75 percent of the total waste generated and implemented an indoor air quality management program. Additionally, construction materials were selected to minimize or eliminate the presence of volatile organic compounds both during and after construction.

Implementing sustainable practices continued beyond the construction of the building. Upon completion, a separate team from AEI provided commissioning services for the facility. Commissioning exercises were conducted over a period of several months during both spring/summer and fall/winter periods. The process resulted in energy savings of just under 40 percent (measured in BTUs/GSF). Measurement and verification (M&V) procedures were also put into place using Informing Ecological Design's Sensedat™ meters and software. A unique facet of the M&V plan allows for individual building occupants to view gas, electricity and water consumption information at their desk. Designers of the system hope this consumption feedback will provide occupants with valuable information which they can use to modify their own resource use patterns, further enhancing the operating efficiency of the building.


### Details on Cost

The project's sustainable design components not only have an array of benefits but also financial costs. Components or processes that represented cost additions to the project include: daylighting, commissioning, DOE2 analysis, green power, construction waste management, CO<sub>2</sub> monitoring, indoor air quality enhancements (air handler filtration) and measurement and verification. However, design synergies enabled the overall cost addition to be relatively negligible.

The daylighting scheme and corresponding air handling unit size represent just such a synergistic relationship. Conventional glazing, a low-e glass with high transmittance values, was \$10,667 less expensive than the glass that was chosen for this facility. The low solar transmittance values of the glazing allowed the mechanical system to be downsized by 10 tons – from two 55-ton air-handling units to two 50-ton units. This decrease in mechanical equipment size saved the project \$10,000. The trade off enabled the project to significantly upgrade a readily perceivable building element for minimal cost without compromising any mechanical performance.

When completed, the project's sustainable elements represented an additional cost of \$42,000. This figure includes \$2,167 for daylighting and controls, \$15,000 for commissioning, \$8,800 for DOE2 analysis, \$8,000 for green power (60 percent of the building electrical power), \$4,500 for CO<sub>2</sub> monitoring, \$3,500 for indoor air quality enhancements, and just \$12 for

construction waste management. In all the costs of sustainability measures represented less than one percent of the project budget and had a two-year payback.

The AEI corporate office project is currently being reviewed by the USGBC and hopes to attain a basic LEED™ certification. 

*Mike Walters leads the sustainable design initiative at Affiliated Engineers, Inc., which focuses on providing sustainable design solutions to clients throughout the country. Mr. Walters is a graduate of the Milwaukee School of Engineering, where he earned a Bachelor of Science degree in architectural engineering. His email address is mwalters@aeieng.com*

*AEI is a national consulting engineering firm specializing in the design of mechanical, electrical, piping and information technology systems for technically complex facilities. In addition to the Madison headquarters, the firm has offices in California, Florida, North Carolina, Washington and Washington DC.*



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# The 2003 WSPE Discovery Conference





# The Dane County Justice Center

## An Energy Efficient Courthouse Through Whole Building Design

By Prasad Vaidya, The Weidt Group, and Sherrie Gruder, University of Wisconsin-Extension



The Dane County Justice Center, a 216,000 SF, \$43 million facility, was the first building project to fall under the Dane County Green Building Policy. Passed in April, 2000, this policy requires that all new and renovated county facilities be built according to sustainable design principles, to protect human health, be environmentally responsible and fiscally prudent over the life of the building. This was a challenging project to initiate sustainability on, due to site and budget constraints and a design team that was attempting green building for the first time. Due to the determination of the owner, Dane County Executive Kathleen Falk, these challenges are being met to achieve a LEED™ certifiable level of sustainability. The County Executive allocated one per cent of the budget to green building and appointed a green champion to help oversee that aspect of the project. She required an accounting of sustainable design integration at each stage of the process.

County officials, the green champion, and The Durrant Group collaborated with The Weidt Group, an energy-consulting firm from Minnesota, to create a sustainable building design. Using LEED™ as a design guide, a rating system developed by the US Green Building Council, the building design addresses site and water issues, energy efficiency, indoor environmental quality, and materials and waste. A goal setting meeting of the owners, occupants, facility managers, design team and utility established the green priorities for the project. Constant vigilance on the part of the owner and the green champion ensured that the design was assessed against LEED criteria periodically. The team met several times during each stage of the process to make decisions based on those

priorities. A collaborative approach for producing an integrated design can be challenging for traditional AE firms used to a linear approach. The expanded design team requires that the AE firm(s) work as much with the sustainable design consultants as with the owners.

***“This is the single most comprehensive building project Dane County has undertaken to conserve resources...”***

The UW-Extension specialist helped educate the owner and the team, and concentrated on the construction waste management effort and materials specifications. In the deconstruction phase, a 99 percent diversion from landfills was achieved through reuse and recycling of 6,900 tons of material from a five-story office building and a two-story office/house. The Weidt Group brought energy efficiency and daylighting design experience to the project. The design is expected to save 37 percent annual operating energy, while the annual electric consumption will be reduced by 50 percent<sup>1</sup>. The building evolved through an iterative process of analysis and design.

A triangular site in Madison with height restrictions and a quarter million square feet space requirement made for a building mass that compromised solar orientation. This situation was improved upon by appropriate interior space

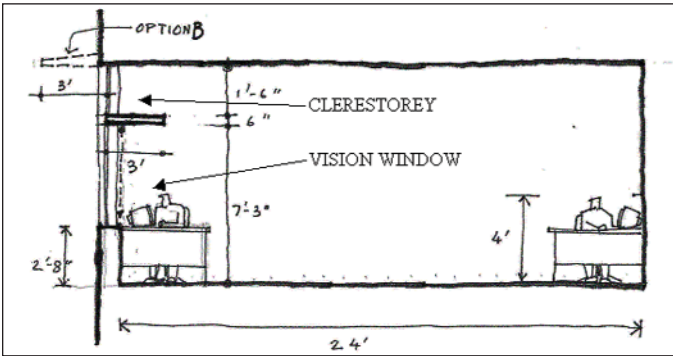
planning and window design. Circulation corridors where sun penetration is not an issue are placed along the long west-facing hypotenuse of the building plan. Sun penetration analysis was used to arrive at the fenestration and shading design that provides adequate shading while allowing diffuse daylight in the offices. Once access to daylight was achieved, the energy efficiency effort was focused on optimizing the performance of building systems such as building envelope, lighting, daylighting controls, and mechanical efficiency and controls.

The Weidt Group facilitated an open-ended whole building consulting approach, where 55 conservation strategies were analyzed. Information in the form of energy savings based on computer simulations, and on the implementation of the strategies was provided for each strategy. The architects and engineers estimated the cost of implementing the strategies. The energy results and costs came together in an interactive tool that helped decision-making in a collaborative meeting attended by owners, occupants, building operators and designers. Costs and benefits of alternative systems were traded off against each other in an effort to create alternative bundles of strategies that bracketed a range of energy-saving solutions. The annual energy savings for the bundles ranged from 14 percent to 37 percent.

The county chose to implement the most aggressive conservation bundle consisting of

- ▲ Low E glazing, light shelves to even the distribution of daylight
- ▲ Automated daylighting controls to turn off electric lights at the perimeter
- ▲ Indirect lighting systems that achieve a

FIGURE 1: SUN-PENETRATION ANALYSIS OF JUDGES SUITE



lighting power density of 1.06 watt per square foot (compared to 1.7 watts per square foot for the base), occupancy sensors, multi-level switching, and periodic nighttime sweeps to turn off lights.

- ▲ An efficient centrifugal chiller, air handling units situated on every floor that reduce the duct lengths and fan energy, highest efficiency motors with variable frequency drives, demand control ventilation for all floors including the garage.

While the above systems were upgraded, the insulation levels were maintained at no higher than code. This decision was based on computer simulations that demonstrated savings due to increased insulation were small with 15 to 25 year payback periods. The chosen strategy bundle is expected to save \$96,500 or 37 percent in annual energy costs compared to a WI energy code compliant building at a simple payback of 4.8 years. This bundle of strategies also reduces the annual electric peak load of the building by 39 percent.

As the design proceeds into construction, a grant from the Wisconsin Focus on Energy provides for additional services to ensure these savings. The construction documents are being reviewed by The Weidt Group so that any omissions may be caught before the project goes off the drawing boards. Once the building construction is complete, the equipment installed will be checked so that the savings predicted become a reality.

Energy efficient design has a wide range of benefits including cost savings, reduced environmental impacts and improved indoor environmental quality. At the most immediate level it reduces annual operating costs of the building. It is good business practice to invest in building systems that save on utility bills at a payback of five years for a building that is expected to operate for at least 50 years. Reducing energy consumption also reduces the resources that are consumed to produce that energy and the pollution that results from burning fossil fuels for generation. Reducing peak demand reduces the need for new power plants and exploration of fuel resources. Since utilities bring on the "dirtiest" power plants to supplement generation at peak times, reducing peak keeps the dirtiest power away. Every unit of energy saved is a unit of energy resource made available. An additional benefit is that many energy conservation strategies like daylighting and demand control ventilation equipment improve the quality of the work environment. Combined with elimination of indoor air contaminants through specification of green, nontoxic materials, it is shown to decrease absenteeism.

*"This is the single most comprehensive building project Dane County has undertaken to conserve resources and energy and keep valuable materials out of our landfill. In doing so, we're using the materials, saving money, and extending the life of our landfill."* –County Executive Falk.

This project is a stellar example of the role partnership played in bringing about efficiency measures into the building at the design stage. This project walked the tough line between aesthetics, the design team's

FIGURE 2: ONE OF THE MANY SCHEMATICS ANALYZED FOR SUN PENETRATION

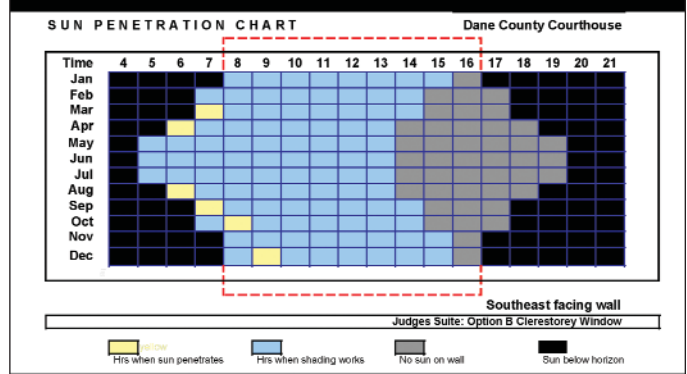


FIGURE 3: RENDERING OF SOUTHEAST FAÇADE



experience, and the budget on one side, and energy efficiency on the other. Understanding the design team's standard practice and providing flexibility in design and efficiency options may have been the winner. Success in such initiatives must not only consider energy savings, but also address the design team's ability to implement the conservation measures and the users' desire to operate the building accordingly.

When the design team and energy efficiency consultants act as partners, they can create buildings that not only meet the client's needs, but also achieve high levels of energy efficiency. Replicating success through subsequent partnerships will help reduce the risks for all the stakeholders and increase the savings in future.

*Prasad Vaidya is an energy analyst with The Weidt Group. Sherrie Gruder is a sustainable design specialist with UW-Extension Solid and Hazardous Waste Education Center. She is on the oversight committee for the Dane County Justice Center and is the green champion on the project.*

*The Weidt Group is a consulting firm with complimentary specialties in architectural design, energy, and software. Founded in 1977 by John Weidt, AIA, the firm consults with other architects and engineers to create environmentally appropriate buildings; it conducts environmental research and analysis of buildings, and it creates software to help architects and engineers make buildings more efficiently. The staff of 30 people includes architects, engineers, and programmers who reside in a bright, naturally lighted space overlooking a wetlands area in Minnetonka, Minnesota.*

<sup>1</sup> The energy calculations and savings mentioned here include the plug loads for the building. If the Energy Cost Budget method, required by LEED™ for calculating savings, were to be used, the percent savings would be higher.

# Changes in State Storm Water Rules

## New Rules Will Affect Many Municipalities, Construction Sites

By Eric Rortvedt, DNR Storm Water Program Coordinator



**M**any municipalities and construction sites disturbing one acre of land would be required to control sediment and other pollutants carried in storm water under proposed rule revisions. The state rules are being changed to conform to new federal storm water requirements that took effect on March 10, 2003, that seek to reduce pollutants from municipalities and construction sites that can be carried by storm water runoff into Wisconsin lakes and rivers.

The proposed revisions to Chapter NR 216 of the Wisconsin Administrative Code would significantly increase the number of construction sites and municipalities that must get permits to control their storm water. The changes also would require many industrial facilities to certify that they do not discharge contaminated storm water, and would increase the fees for their storm water permits. It has been ten years since such fees were adjusted and a fee increase is necessary to manage the program.

Everyone contributes to storm water pollution but most people don't realize it. Pollution comes from many sources including sediment from construction, vehicle emissions and tiny pieces of tires and brakes that wear down, lawn fertilizer, road salt and sand, and yard waste that can be washed away. Add up all the small amounts that individuals contribute and it becomes a large amount of storm water pollution in an urbanized area. These rules will require municipalities develop a plan and implement practices to reduce pollution and also take steps to educate homeowners and businesses on ways to prevent storm water pollution.

These proposed changes would align state rules with federal requirements known as "Phase II" storm water requirements. Federal Phase I regulations, adopted in 1990 by the U.S.

Environmental Protection Agency, required cities with more than 100,000 people, certain industries and construction sites disturbing five or more acres of land to get permit coverage that requires control of storm water pollution. Wisconsin subsequently extended permit requirements to 70 more communities that were within Great Lakes areas of concern, in priority impaired watersheds with 50,000 or more residents, and to municipalities that were significantly contributing storm water pollution to Wisconsin waters. With Phase II, there will be about 250 municipalities in Wisconsin that will be required to obtain permit coverage to implement measures to control storm water pollution.


*Just think how our streets and parking lots look clean after a rain storm. Where does that dirt go?*

Just think how our streets and parking lots look clean after a rain storm. Where does that dirt go? Sometimes it looks like chocolate milk going down our storm sewers and it goes on to pollute our lakes and streams. Getting the storm water controls in place for smaller municipalities and construction sites will be important in helping Wisconsin clean up and protect its waters.

About half of the lakes and river segments on Wisconsin's list of most impaired waters are on the list because of polluted urban runoff.

Specifically, the proposed rules would:

- ▲ Require construction site landowners that disturb one or more acres of land to get coverage under a construction site permit that requires that an erosion control and storm water management plan be developed and implemented to control soil and other pollutants during and after construction. Previously, the requirements applied only to construction sites disturbing five or more acres.
- ▲ Require about 250 Wisconsin municipalities to get permit coverage from DNR that requires them to meet state standards to control pollution that enters their municipal storm water sewer systems. Municipalities located within 16 urbanized areas that have a population of at least 50,000 residents and a density of at least 500 people per square mile face the requirements. By federal law, these municipalities should have turned in their applications by March 10, 2003. Additionally, any municipality with a population of 10,000 or greater must be evaluated for permit coverage.

A copy of the proposed changes and supporting information can be viewed online at [http://www.dnr.state.wi.us/org/water/wm/nps/rules/nr216/nr216\\_revisions.htm](http://www.dnr.state.wi.us/org/water/wm/nps/rules/nr216/nr216_revisions.htm). For more information, contact Eric Rortvedt at 608-264-6273 or Carol Holden at 608-266-0140. 

## Mead & Hunt Appoints New Department Manager



MADISON—Lew Kollmansberger was recently promoted to Manager of Infrastructure Services at Mead & Hunt, a top 500 engineering and architecture firm.

Kollmansberger is a municipal and geotechnical engineer who specializes in preparing geotechnical design reports, performing materials analysis, and civil site and subdivision design and construction.

Kollmansberger's new duties include supervising and managing the infrastructure department's operations, maintaining stability and growth, and creating client and employee satisfaction.

The department currently serves clients ranging from large private residential and commercial developers to local communities. Services in the areas of domestic water, storm water, wastewater, surveying, urban and regional planning, development, construction administration, and financial assistance are provided.

Mead & Hunt provides professional services in the fields of municipal and infrastructure, highway and bridge engineering, aviation engineering, architecture and building engineering, water resource engineering, historic preservation, military engineering, and environmental studies to clients throughout the US. Founded in 1900, Mead & Hunt is a privately held, employee-owned corporation with offices nationwide.

## General Magnaplate Announces ISO 9001 Compliance

Linden, NJ—General Magnaplate has announced the completion of its ISO 9001:2000 registration following a rigorous two year implementation program.

Magnaplate's New Jersey-based headquarters is the first of its facilities to receive the registration and the company expects to roll out the implementation process to its plants in Texas, Wisconsin, California and Ontario, Canada.

Larry Campbell, Assistant Vice President and ISO Management Representative at General Magnaplate, reports, "We are proud to be one of the first companies in our field to have achieved ISO 9001:2000 certification.

"ISO defines a world-class approach to the quality of our processes and products, and compliance is a key step in ensuring our manufacturing facilities adhere to the highest standards in product quality and performance. The registration process required 24 separate procedures from plant operations and the performance of the management team, to dealing with customer complaints and purchasing procedures. As well as improving the quality of our operations, we are confident the process has enabled us to increase our efficiency - which can only mean good news for our customers!"

General Magnaplate Corporation has been a pioneer and world leader in the science of surface enhancement for metals and other substrates for over 50 years.

## Mead & Hunt named to top 100 fastest growing in nation

MADISON—Mead & Hunt ranked number 57 on *The Zweig Letter* Hot Firm 2003 List of the 100 fastest growing architectural, engineering, planning, (A/E/P) and environmental consulting firms in the country. This ranking is based on an equal weighting of percentage revenue growth and dollar revenue growth from 1999 to 2002.

With revenues that rose from \$14.2 million in 1999 to \$24 million in 2002, Mead & Hunt grew 69 percent. The firm employs about 270 people in offices across the nation. Mead & Hunt provides a wide range of services in the areas of infrastructure, transportation, aviation services, architecture and building engineering, water resources, and historic preservation.

In a nationwide survey, Zweig White, an A/E/P business consulting firm, asked A/E/P firms to share their 1999 and 2002 gross revenues. Several hundred firms sent in submissions.

To be eligible for the Hot Firm 2003 List, firms must be based in the United States and derive most of their revenue from the practice of architecture, engineering, planning, environmental consulting, design and construction, or allied disciplines. Eligible firms also had to be in business as of January 1, 1999, and had to have gross revenue of \$1 million or more in 1999.

The top 100 firms have varying backgrounds. Some are strictly architecture, engineering, or environmental consulting firms. Others are multi-discipline or full-service firms, offering those services and more. Firms on this year's list reported 2002 annual revenue from \$6 million to \$4 billion.

## University of Wisconsin-Madison Wins 2003 National Concrete Canoe Competition

The University of Wisconsin-Madison overcame torrential rains, a change in race venue and challenging new rules to capture its first national title at the 16th annual ASCE/MBT National Concrete Canoe Competition. The team's canoe, the Chequamegon, surpassed entries from 23 other universities and colleges in design, construction and overall performance. And UW was not the only Wisconsin team to finish in the top ten. Milwaukee School of Engineering's team finished in eighth place.

The three-day competition, hosted by Drexel University in Philadelphia, proved to be the most dramatic in the event's history when the original race site on the Schuylkill River was flooded due to intense rainfall during the first two days of the event.

Just 24 hours before the start of race day, the fast currents and high water on the Schuylkill River destroyed the docks and flooded the spectator areas at the original race site in Fairmount Park. The city of brotherly love, and local park and planning officials, salvaged the races, worth 30 percent of each team's overall score, when it granted use of

**Continued on page 16.**



## What's Inside Your Financial Management Toolbox?

By Tim O'Grady, CPA

As the construction season heats up this summer, engineers need to inventory what's inside their financial management toolbox. Most owners and managers of engineering firms are presented with a plethora of reports painting a financial picture of where their organization has been and where it will be. The unfortunate fact is that most owners and managers don't have a financial background and often don't understand how to analyze the financial data presented to them.

Financial ratios are one of the most effective tools to help you determine the financial health of your company. Although there are hundreds of ratios that may be used, the following key financial ratios are important to understand and monitor.

### Cash Flow Ratios

Cash flow can be a better indicator of financial well-being than net income. Companies need to identify a trend in declining cash flow earlier than a declining profit trend. Normally, cash flow is a strong indicator of future profits.

An important cash flow ratio is the **accounts receivable turnover ratio**. It is calculated by dividing revenue by average

receivables. Companies with higher accounts receivable turnover ratios are collecting receivables in a timely manner, and thus have a greater amount of cash at their disposal. Companies with lower ratios may need to reevaluate their credit and collection policies.

### Liquidity Ratios

Liquidity is a measure of the quality and adequacy of current assets to meet current obligations as they come due.

An important liquidity ratio is the **current ratio**. The current ratio is calculated by dividing total current assets by total current liabilities. This ratio is a rough indication of a company's ability to service its current obligations. Generally, the higher the current ratio, the greater the "cushion" between current obligations and a company's ability to pay them.


### Leverage Ratios

Highly leveraged companies (those with heavy debt in relation to net worth) are more vulnerable to business downturns than those with lower debt to worth positions. Leverage ratios measure this vulnerability.

The **debt to equity ratio** is used to determine leverage. This ratio indicates the extent to which the company funds are supplied by

creditors compared to its owners and is an indicator of the company's long-term debt paying ability. To calculate the debt to equity ratio, divide total liabilities by total equity. Many lenders focus on the debt to equity ratio when considering the amount of financing to extend to a company and the level of risk the company presents to the lender.

Financial ratios can vary greatly by industry. It is imperative that you compare your ratios against similar companies within your industry. Trade organizations can be a useful resource in obtaining average industry ratios.

As you know, having the right tool makes jobs easier, more efficient, and of higher quality. The question is: Do you have the right tools in your financial management toolbox? 

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*Tim O'Grady is a Supervisor with Smith & Gesteland, LLP, a CPA and business consulting firm with offices in Madison, Sun Prairie and Columbus. He is a member of the firm's Construction Industry Services Group. He can be reached at (608) 836-7500 or [tim.ogrady@sgcpa.com](mailto:tim.ogrady@sgcpa.com).*


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**Newsmakers**  
*continued from page 15.*

the lake at the Franklin D. Roosevelt Park as the new race venue. Ironically, in the language of the Ojibwa Native American tribe, Chequamegon means "place of shallow water." The 145-pound, 22-foot Chequamegon proved that through good engineering, concrete can indeed float. For their ingenuity, the UW team earned \$5,000 in scholarship money awarded by Master Builders, Inc., sponsor of the competition since it began in 1988.

With the slalom/endurance and sprint races accounting for only 30 percent of the total score, the remaining 70 percent is based on a design

paper (30 percent), a business presentation (25 percent), and the end product or final racing canoe (15 percent). In addition, the canoes must pass a floatation test in which the students must prove that their canoes do indeed float.

"These civil engineering students are gaining problem-solving and project management skills by demonstrating that concrete is a remarkable and versatile building material as they develop innovative concrete mixes that have numerous applications in the building industry," said Master Builders President and CEO Mike Shydrowski. 

# Legislative Cabinet

*Join the Legislative Cabinet and let your voice be heard in the legislature*

**By Joseph Dresser, PE, Department of Transportation, retired.**

As most are aware, the WSPE Legislative Cabinet was restructured and expanded a few years ago. These changes were made to improve our effectiveness and revitalize our legislative activities. While WSPE has long supported a Legislative Cabinet within its organizational structure, it was concluded that the inclusion of other professional/technical organizations with similar interests would be beneficial to all involved.


Working with our initial partner organization, the American Society of Civil Engineers (ASCE), the Cabinet drafted new Rules of Operation which were approved by the Boards of Directors of both organizations. The Cabinet now consists of the AIPG (Geologists); the AIA (Architects); and ACEC (Consultants). In addition, several other organizations have expressed interest in membership.

In the legislature, the budget deficit has dominated activity to the exclusion of everything else. However several issues that were active in previous sessions are likely to re-emerge and the Cabinet is monitoring all legislative activity through the daily Wheeler Report.

The Cabinet and its member organizations participated in two major events this last spring: Geology Day sponsored by AIPG in March; and the release of the ASCE Report Card on the Wisconsin Infrastructure which was released in May. Both events were major efforts by these respective

organizations and were held in the rotunda of the state capitol. Both were well attended by the public and legislators and staff, and media coverage was good.

One of the key functions of the Legislative Cabinet is to work in partnership with government at all levels to assist government leaders and agencies on issues where the specialized expertise of professionals can be of unique value. With more member organizations working together, we can be more effective in achieving what we collectively believe to be in the best interests of the public and profession. The Cabinet has initially decided on ten committees consisting of experts in these fields and is seeking volunteers in each of the following areas: Structural; Transportation/Urban Planning; Environment/Water Resources; Management/Business; Construction; Geo-Technology; Licensure; Building Code; Budget; Land Use.

If you would be willing to serve on one or more of these committees, let Fritz Longfield or Joe Dresser know. Each committee will be reviewing bills that are proposed in their subject area, and will be making recommendations for action by the full Legislative Committee and its member organizations. 

*Let Joe Dresser ([jdpe@charter.net](mailto:jdpe@charter.net)) know if you would be willing to serve on one or more of these committees. Each committee will be reviewing bills that are proposed in their subject area, and will be making recommendations for actions by the Cabinet and its member organizations.*

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# Legal Perspective

## *When Professional Engineering Recommendations are Ignored, Who Pays?*

**By Robert J. Kay, Kay and Andersen, S.C., Madison**

In October of 2001, the Wisconsin Court of Appeals decided a complex case brought by 80 residents of the City of Sheboygan against the City and its insurance carriers. These residents represented 46 properties which sustained substantial damage as a result of flooding. The residents asserted that the City of Sheboygan was responsible for the flooding.

The residents lived in an area of Sheboygan served by a storm sewer system. The City Engineer's Office designed the sewer system. Following abnormally heavy rainstorms in 1986, the City of Sheboygan authorized an engineering study of the sewer system. In 1988 it authorized a second engineering study of the system. These studies recommended implementing improvements in the sewer system to accommodate a 100-year flood. After the studies were completed, the City entered into easements with many of the residents, granting the City the right to construct, install, maintain and repair a sewer system. In the easement the following language appeared: "[I]t is understood that the [City of Sheboygan] shall be responsible for any wrongful or negligent act or omission of the [City] or its agents or employees in the course of their employment."

The area served by the sewer system was subjected to unusual and abnormally heavy rain in 1998 resulting in the foundations of homes collapsing inward and in one case, a home collapsed entirely. The residents brought an action against the City in negligence, alleging that the City had failed to design, construct, maintain and operate a storm sewer system with sufficient capacity, and was negligent in failing to follow the recommendation of the engineering consultants who recommended a system capable of handling a 100-year flood. The City responded that even if the allegations were true, the City was immune from liability because the acts of designing, planning and implementing a sewer

system are legislative acts protected under the Doctrine of Governmental Immunity.

The Court of Appeals reviewed the Doctrine of Governmental Immunity which is found in the Wisconsin Statutes, §893.80(4). Under that Statute a governmental body is immune from suit when the act complained of is discretionary as opposed to merely ministerial. A discretionary act is one performed in the exercise of legislative, quasi-legislative, judicial, or quasi-judicial activity.

***The area served by the sewer system was subjected to unusual and abnormally heavy rain in 1998 resulting in the foundations of homes collapsing inward and in one case, a home collapsed entirely.***


In previous decisions, the Court had already concluded that the act of designing, planning and implementing a sewer system was a legislative act stating: "Where, when and how to build sewer systems are legislative determinations imposed upon a governmental body. It is not for the court to be judge or jury to 'second guess' them in these determinations nor define that they are liable for negligence." The Court found these prior decisions to be dispositive and concluded that the City of Sheboygan's decision to implement and maintain a sewer system with a capacity to handle only a one year storm event was protected by the Doctrine of Governmental

Immunity. Further, the Court held that the City's refusal to adopt the plans recommended by its consultants was also a legislative determination that immunized the City from liability.

Finally, the Court of Appeals held that the words expressed in the easements did not constitute a waiver of the governmental immunity because it was not clear that the language in the easements contained an express waiver of immunity. The Court held that the easements simply expressed the City's willingness to be liable for negligent acts occurring during the work allowed by the easements, such as negligent trenching, etc., but not for the overall planning and design decisions of the sewer system. Since the residents did not allege any negligent acts with respect to the installation of the sewer system, but only with respect to the original design and the refusal of the City to follow its consultant's advice, the Court concluded that the City's governmental immunity was not waived by the easements.

Finally, the Court held that the City's governmental immunity extended to the City Engineer, holding that the City Engineer had not exercised any independent professional judgment and was protected by the City's governmental immunity.

In summing up its decision, the Court stated: "While the decision to refuse to implement a 100-year storm event system has become increasingly untenable, it is nonetheless an exercise of legislative judgment and discretion. The remedy for the residents, therefore, lies in their power to vote rather than in the judicial system."

Clearly, professional engineering decisions of great substance are often ignored, and the remedy for such disregard does not lie with the courts. 





# Mailbox

## Welcome Back, Engineering Professional

After my retirement from the engineering profession ten years ago, I lost track of you. Or maybe you lost track of me, I'm not sure. Anyway, it is good to see you are up and running again. Thanks for putting my name on your mailing list. I am looking forward to reading *Engineering Professional*.

Gordon Mross, PE (ret.)  
Waukesha

I read an article in your most recent magazine about payments made to the general

contractor and how it is then the general's obligation to pay the subcontractors. Once the general has been properly paid (with appropriate records) the subcontractor cannot go after the owner of the project for payment and must get their payment from the general. I meant to save the issue but must have thrown it away during my last office cleaning. Is there any chance I could get a copy of this article faxed to me?

Thank you for your time,  
Scott Schmidt, PE, RLS  
Washington County Engineer

*Glad you found attorney Robert Kay's column ("Misuse of Construction Monies", Legal Perspective, May/June) informative. A copy of the magazine to replace the one you "cleaned" is in the mail.—editor*

Send letters to [EngEditor@engineeringprofessional.com](mailto:EngEditor@engineeringprofessional.com) or Editor, *Engineering Professional*, 7044 S. 13th Street, Oak Creek, WI 53154-1429. Letters may be edited for space considerations.

**How important is incorporating "green" principles into building projects? Let us know what you think. Letters will be published in the *Engineering Professional Mailbox*.**

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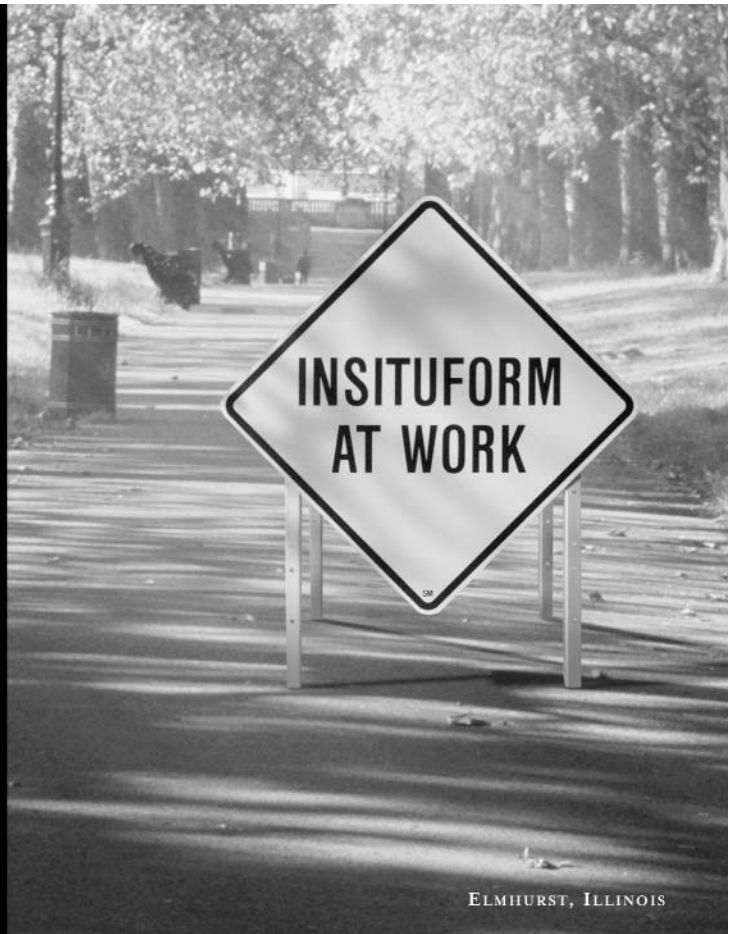
**Constituents are fickle.** They want the best public works as long as it doesn't inconvenience them. Which is why the city of Elmhurst voted for Insituform's 30 years of trenchless technology experience to repair its sewer lines. While digging and replacing sewer lines can take weeks, we had service back up and running before residents got home from work the same day. No disruptions. No property restoration. No angry phone calls. And best of all, our speed and experience meant that Elmhurst's entire repair efforts were completed on schedule and within budget. To see how we can save tax dollars and headaches for your city, call us at 800-234-2992 or visit our website at [www.insituform.com](http://www.insituform.com). **Because only our experience shows.**



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