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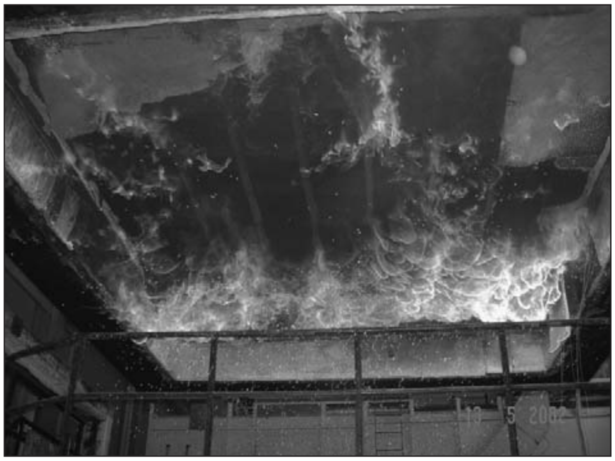
Fire and acoustics project yields important new information for construction industry

Highlights

IRC and a group of industry partners have just completed the second phase of a comprehensive collaborative project that will provide major benefits to both parties and to the construction industry as a whole. (See related stories in *Construction Innovation*, Volume 2 Number 3 and Volume 4 Number 1.)



One of 60 floor assemblies, typical of those used in residential construction, undergoing a full-scale fire test at IRC

The first phase of the project, completed in 1998, led to a better understanding of the fire and acoustical performance of traditional building systems used in residential construction. Specifically, fire-resistance ratings (FRR) and noise-control ratings for 177 generic floor assemblies were added in 2002 to the National Building Code (NBC) Part 9, Appendix A. This increased number of assemblies has led to greater choice and the potential for better performance at reduced cost to designers, builders and consumers.

However, most of the new entries in the expanded table in the NBC give updated information about the acoustical performance of the assemblies but not about their fire performance. To address this deficiency, Phase 2 of the project was launched, with the intent of "filling in the blanks" by providing the technical information necessary to determine the FRRs for these assemblies as well as some others.

In this second phase, fire researchers sought to confirm some of the findings of Phase 1—those concerning support conditions, and the type of insulating material used and its method of installation—and the way they affect fire-resistance ratings. When all four edges of the gypsum board were supported and the screws set back from the edges, and when sprayed-on cellulose was used, the FRRs improved dramatically. Both findings are related to the issue of keeping the insulating material in place longer.

In addition, fire researchers confirmed that:

- Type X gypsum board plays a key role in the fire resistance of the floor assembly, as it is the first line of defence in protecting the framing and sub-floor. To improve the fire resistance of floor assemblies, attention should be focused on the spacing of either the framing or the resilient channels where the gypsum board is attached, as well as on the number of gypsum board layers in the floor. (The closer the spacing, the more screws used to support the gypsum board; hence the better the fire resistance.)
- a second layer of gypsum board added to a floor assembly with only one layer of Type X gypsum board provides more fire resistance than the addition of a second layer of sub-floor.

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Construction codes

Decisions made on remaining proposed code changes

The Canadian Commission on Building and Fire Codes (CCBFC) approved most of the technical changes to the national model codes at its April 2004 meeting. (See cover article in the September 2004 issue of *Construction Innovation*.) However, approval of two sets of significant proposed changes was delayed at that time, pending further discussion with stakeholders. These proposed changes were related to:

- seismic design as found in the National Building Code (NBC) Part 4 Structural Design; and
- maximum hot water temperature. A temperature of 49°C at fixture outlets in residential occupancies in the National Plumbing Code (NPC) had been proposed.

Structural design changes. Recent earthquake research has allowed for advanced mapping of seismic risk in Canada, especially on the East Coast. This work has in turn led to proposed changes to Part 4 of the NBC to enhance the protection of tall buildings in central and eastern regions of the country under seismic conditions.

One key change is the adoption of dynamic analysis instead of static analysis as the default design procedure under certain conditions. Dynamic analysis is a more precise design approach that takes into consideration building-specific factors, such as height and configuration; it will be required for certain buildings where the seismic risk is moderate to high, and where there is a low earthquake risk but soil conditions are poor.

The new requirements are most likely to affect the design of tall buildings in major urban areas located in active seismic zones, such as Ottawa-Gatineau, Montreal and Quebec City.

After a careful review of the impact of such changes on design and construction costs, the CCBFC approved the proposed seismic design changes in October 2004.

Maximum hot water temperature at fixtures. A proposed change to the NPC to establish a maximum hot water temperature of 49°C at fixture outlets in residential occupancies generated a significant number of negative CCBFC votes, which led to ongoing consultations with stakeholders throughout the summer. Objections from industry and some provincial governments were not able to be resolved prior to the deadline for code changes for the 2005 edition.

In October 2004 the CCBFC withdrew the proposed change and requested the formation of a national task group with broad representation to examine the health and safety risks associated with hot water delivery in buildings.

The task group began its work earlier this year by reviewing the medical information, statistics and circumstances of legionella contamination, as well as information about injuries related to scalding. Proposed technical changes developed by the task group will be examined in terms of their impact on health and safety, and their implications for cost, enforcement and retrofits.

The task group's report and recommendations will be reviewed by the Standing Committee on Building and Plumbing Services (SCBPS). Technical changes subsequently recommended by the SCBPS will be considered by the CCBFC.

For more information, please contact John Archer, Secretary to the CCBFC and PTPACC, at (613) 993-5569, fax (613) 952-4040, or e-mail john.archer@nrc-cnrc.gc.ca.

Canadian Codes Centre setting priorities for the next codes cycle

The Canadian Commission on Building and Fire Codes (CCBFC) and the Provincial Territorial Policy Advisory Committee on Codes (PTPACC) have formed two joint task groups to help set directions for code development in the next codes cycle. The initial meetings of the task groups were held in December 2004.

The first task group is evaluating how well the new coordinated code development process actually worked in the development of the 2005 codes. It will recommend any needed procedural improvements that could facilitate provincial and territorial policy input, joint public consultations and reviews of technical changes in the future.

The second task group will review and prioritize proposed technical issues to ensure that the most urgent and important ones are addressed first.

Both task groups will present their recommendations to the CCBFC at its June 2005 meeting. The CCBFC will then form standing committees and task groups in the fall of 2005, with a view to beginning work in early 2006 on proposed changes for the next editions of the codes.

For more information, please contact John Archer, Secretary to the CCBFC and PTPACC, at (613) 993-5569, fax 952-4040, or e-mail john.archer@nrc-cnrc.gc.ca.

Canada benefits from NRC participation in international code development group

The next edition of Canada's national model codes (NBC, NFC and NPC) will be published this summer. In addition to the technical changes normally included in any new edition, there is another important feature of these codes: they will be published in an objective-based format.

Canada's move to objective-based codes has been facilitated by its involvement in the Inter-jurisdictional Regulatory Collaboration Committee (IRCC), a group of eight countries engaged in various forms of performance-based regulatory reforms related to buildings. This group, in which NRC acts on behalf of Canada, is very active on the international scene and plays a key role in the development of the concept of performance as it applies to building regulations.

> IRCC member countries are Canada, United States, Norway, Spain, United Kingdom, Japan, Australia and New Zealand. Other countries have recently expressed interest in joining IRCC.

NRC's involvement in IRCC and other international initiatives has helped the Canadian Commission on Building and Fire Codes (CCBFC) develop Canada's unique objective-based codes concept. Although the terms used are different, the Canadian concept has much in common with the performance-based codes developed in other countries. In both cases, the codes offer a clear articulation of the objectives and functional statements (requirements) in a format that makes them easier to apply to existing buildings and innovative designs. And in both cases, the objectives and functional statements are of a qualitative nature, which should facilitate the introduction and evaluation of performance-based solutions.

One clear benefit from this compatibility of the Canadian building regulatory system with that of other countries will be the facilitation of international trade and the export of Canadian products, services and technologies.

Collaboration between IRCC members also helps all member countries address difficult code and regulatory issues that may arise in their own jurisdictions. For example, at its last meeting, IRCC members shared information about revolving doors—the safety issues and how to address them—which helped one of the member countries deal with serious incidents through the development of appropriate code requirements. By sharing information about hot water temperature regulations in their countries, IRCC members will also help a new CCBFC task group examine the scalding and legionella issues associated with hot water delivery in Canadian buildings.

As well, IRCC acts as a catalyst to foster discussion on broad policy issues related to building codes and regulations. An IRCC policy summit on performance-based codes in 2003 in Washington, DC addressed various issues, including the cost-effectiveness of performance-based regulations, the danger of causing unintentional consequences and the need for new regulatory systems to monitor outcomes and to be flexible in terms of adapting to changing conditions.

A summit being organized for September 2005 will focus on sustainability. If you would like to know more about IRCC or this summit, please consult IRCC's Web site www.ircc.gov.au.

For more information, please contact Denis Bergeron at (613) 993-5659, fax (613) 952-4040, or e-mail denis.bergeron@nrc-cnrc.gc.ca.

> To learn more about the conversion of the national model codes into an objective-based format please consult the national model codes Web site www.nationalcodes.ca and see also previous issues of *Construction Innovation*:
> Volume 3 Number 1, Fall 1997
> Volume 3 Number 4, Summer 1998
> Volume 4 Number 1, Fall 1998
> Volume 4 Number 4, Fall 1999
> Volume 6 Number 1, Winter 2001

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Carleton and NRC team up to expand fire research facilities

Carleton University, in partnership with NRC, the Ottawa Fire Services and the Toronto Transit Commission, with resources obtained from the Canada Foundation for Innovation and the Ontario Innovation Trust, has just completed construction of full-scale fire research facilities adjacent to existing NRC facilities in Almonte, Ontario. The new facilities, combined with the capabilities of the existing ones, provide a unique world-class resource for the Canadian construction and transportation industries.

The new facilities include:

- a 10-storey atrium with approximate dimensions of 20 x 20 x 26.5 m high. The atrium shares a wall with the existing 10-storey tower facility. The expanded facility will provide new opportunities for investigating smoke management in high-rise buildings and large-volume spaces.
- a new burn hall with dimensions of 20 x 20 x 12 m high. This hall can be used to investigate fire scenarios involving large fires.
- a tunnel measuring 10 m wide, 5.5 m high and 37 m long for conducting tests that realistically simulate fires in roadway and mass-transit tunnels.

Construction of full-scale fire research facilities adjacent to existing NRC facilities at Almonte, Ontario is underway.

Smoke produced in all three new facilities can be collected and exhausted through a high-capacity fan system (160 m^3/s) to measure the heat-release rate. This exhaust system can also be used to simulate smoke-management systems used in atrium applications and in the emergency ventilation systems used in tunnels.

"The expanded test facilities will provide new opportunities for research that can improve fire safety in residential and commercial buildings, as well as in transportation facilities," said Prof. George Hadjisophocleous, Carleton University. "They will also provide a unique opportunity for training students."

For more information on the Carleton University program in fire-safety engineering, please visit the Web site at http://www.carleton.ca/~ghadjiso/.

For further information on the full-scale fire research facilities, please contact Mr. Bruce Taber at (613) 256-4464, fax (613) 256-1309, or e-mail bruce.taber@nrc-cnrc.gc.ca.

NRC to hold workshop on design fires in conjunction with Carleton University short course on fire and explosions

The increasing use of engineering approaches to the design of fire-protection systems means that appropriate design fires must be determined.

A design fire is a quantitative description of the characteristics of a fire, such as the rate of release of heat energy, the size of the fire and its rate of spread, the yield of products of combustion, and hot gas temperatures; it is based on fire scenarios that replicate real fires. The central question concerning design fires is: How can researchers be confident that the design fires they are using do in fact approximate reality?

In an attempt to address the issues and challenges surrounding design fires, the National Research Council of Canada (NRC), in collaboration with Carleton University and Forintek Canada Corp., will hold a one-day workshop on design fires on May 10, 2005. A number of topics will be discussed, including:

- the definition of a design fire;
- the role of the design fire in building regulation;
- the role of existing international committees in providing guidance on the selection of design fires;
- the technical issues involved in developing appropriate design fires.

A number of invited speakers will make presentations and there will be a panel discussion.

In conjunction with the NRC workshop on design fires, Carleton University will run a short course on fire and explosion investigations, to be held at the University from May 11 to 13, 2005.

These two workshops are aimed at fire-protection engineers, architects, building officials, code consultants, building science practitioners and students in fire-safety programs.

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Fire and acoustics project yields important new information for construction industry

Continued from cover

- concrete topping added above the sub-floor slightly increases the fire resistance.
- an increase in live load decreases the fire resistance.
- floor assemblies with either rock-fibre or cellulose-fibre insulating material provided more fire resistance than those with glass-fibre insulating material.

Acoustics portion of project

With respect to the acoustics portion of Phase 2 of the project, the goals were to examine areas in which information was lacking, and to obtain reliable sound ratings for specific floors that had already obtained adequate fire-resistance ratings.

Acoustics researchers also set out to resolve some of the inconsistencies in results from Phase 1. In particular, it was not clear whether the different types of insulating (sound-absorbing) material—rock, cellulose and glass fibre—gave consistently different sound transmission ratings (sound transmission class, STC, and impact insulation class, IIC) in otherwise identical floor systems. Also, the few results available with 12.7-mm-thick gypsum board had somewhat higher STC ratings than expected. While the first phase of the project was extensive, not all material variations were systematically investigated.

In this second phase, measurements of airborne and impact sound transmission (STC and IIC) were made through approximately 60 floor assemblies. The analysis of the combined data (from both phases of the project) led to a better understanding of the factors that influence sound insulation, showing that:

- in practice, the thickness of Type X gypsum board used in the ceiling does not affect the STC or IIC ratings significantly.
- the type of insulating material sometimes changed the STC or IIC and other times did not; the conclusion being that it is not an important factor for determining these ratings.

Program for estimating assembly ratings

An important additional outcome of Phase 2 is a program for estimating sound transmission class, impact insulation class, and some related ISO ratings, which was developed for floors with resilient metal channels and insulating material. The presence of both of these elements was clearly shown to be essential for achieving high STC ratings, with minimum-weight assemblies.

The program is based on mathematical expressions fitted to the data from both phases of the project to predict expected values for the NRC laboratory facility. From various menus, users can select sub-floor materials, framing and ceiling details, resilient channel disposition, and the thickness and type of sound-absorbing material for common floor assemblies. A similar analysis was done for previous IRC projects that studied sound transmission through gypsum board walls. As a result, the program also includes algorithms for estimating sound transmission through this type of wall.

The beta version of the program is now available on the Web at http://irc.nrc-cnrc.gc.ca/ie/floors/index_e.html.

Next steps

The findings from this multidisciplinary project are being compiled and an ad hoc committee of project partners is preparing a submission for changes to the NBC. This code change request will be considered by the appropriate standing committees after the publication of the 2005 NBC, for possible inclusion in the next edition.

For more information about the fire portion of this project, please contact Dr. Mohamed Sultan at (613) 993-9771, fax (613) 954-0483, or e-mail mohamed.sultan@nrc-cnrc.gc.ca; for more information about the acoustics portion, please contact Dr. Alf Warnock at (613) 993-9370, fax (613) 954-0483, or e-mail alf.warnock@nrc-cnrc.gc.ca.

Project partners

Canada Mortgage and Housing Corporation, Canadian Steel Construction Council, Canadian Wood Council, Cellulose Insulation Manufacturers Association of Canada, Cellulose Insulation Manufacturers Association (U.S.), Forintek Canada Corporation, Gypsum Association (U.S.), Gypsum Manufacturers of Canada, Ontario Ministry of Municipal Affairs and Housing, Owens-Corning Canada, Roxul Inc., Truss Plate Institute of Canada, Truss Plate Institute (U.S.).

NRC and Carleton University to hold workshop on design fires and short course on fire and explosions

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For more information about the Workshop on Design Fires go to http://irc.nrc-cnrc.gc.ca/fr/designfiresworkshop/index_e.html. If you wish to attend, please contact Dr. Noureddine Bénichou at (613) 993-7229, fax (613) 954-0483, or e-mail noureddine benichou@nrc-cnrc.gc.ca.

For more information about the Carleton University Short Course Fire and Explosion Investigations go to http://www.carleton.ca/~ghadjiso/. If you wish to attend, please contact Prof. George Hadjisophocleous at (613) 520-2600 Ext. 5801, fax (613) 520-3951, or e-mail george_hadjisophocleous@carleton.ca.

Now available!

1-D version of *hyg*IRC model for assessing wall moisture performance

IRC continues to develop a state-of-the-art model, *hyg*IRC, that can compare the moisture and thermal performance of a proposed wall design to that of another wall with a known performance track record (see *Construction Innovation*, September 2003). And now a 1-D version of this model is available (see sidebar for details on how to purchase).

The framework of *hyg*IRC 1-D makes it possible to conduct case studies in which several parameters, such as climate, material and configuration, are changed one at a time to gauge the sensitivity of the wall to these different inputs. This allows designers to explore various "what-if" scenarios—for example, what if the stucco cladding were replaced with acrylic stucco. However, situations involving air leakage, water leakage or gravity, or any others that need to be examined in two dimensions, are still best handled using the original version of *hyg*IRC.

*Hyg*IRC 1-D can simulate the response of each building envelope element to changing environmental conditions on either side of the envelope on an hourly basis, producing information on the temperature and relative humidity distributions within the wall assembly and the changes in both over time.

At the core of *hyg*IRC 1-D, and the original *hyg*IRC, is the recently benchmarked solver. This is the "brains" (programmed mathematical equations) of the models, simultaneously solving the heat and mass transfer equations. *Hyg*IRC 1-D comprises a weather database that contains 30 to 40 years of hourly weather data for 19 Canadian and six U.S. cities; models to simulate interior temperature and relative humidity conditions; and a material database that lists the hygrothermal properties of 80 common construction materials (the most up to date in North America) as measured at IRC (see *Construction Innovation*, December 2003).

In addition to the extensive weather and material properties databases available with *hyg*IRC 1-D, the model allows users to input their own data on weather, interior conditions and material properties and also provides them with easy-to-use tools for output analysis. With *hyg*IRC 1-D, it is possible to view:

- an animated "snapshot" of the wall response over time, i.e., the spatial distribution of moisture or temperature;
- the time history of individual wall layers or the entire wall assembly over the entire course of the simulation for various parameters, such as moisture content or temperature;
- cumulative indices of moisture or temperature in a wall, or in an element of the wall, including the number of freeze-thaw cycles that occur (freeze-thaw index) and the amount of moisture, in terms of relative humidity and temperature, that accumulates over the course of the simulation (RHT index). These output indices were originally developed for use with the *hyg*IRC model (see *Construction Innovation*, March 2003 and September 2003).

Specific questions about the *hyg*IRC 1-D model can be directed to Steve Cornick at (613) 990-0460, fax (613) 998-6802, or e-mail steve.cornick@nrc-cnrc.gc.ca.

How to Order *hyg*IRC 1-D

The powerful *hyg*IRC 1-D software is available on CD for the low price of $150, much lower than the cost of comparable models.

Ordering is easy. Simply access the *hyg*IRC order form at http://irc.nrc-cnrc.gc.ca/bes/hygIRC/purchase.html. You will find ordering options at the bottom of the form.

CD sales are subject to shipping and handling charges and GST.

Special Offer: If you have attended one of IRC's Building Science Insight seminars, you will receive a discount of $25.

Construction Technology Updates 61, 62 and 63 now on the Web

The Updates address various aspects of the open-plan office (workstation design, lighting design and acoustical design). They are now available in print and on the Web at http://irc.nrc-cnrc.gc.ca/catalogue/ctu.html

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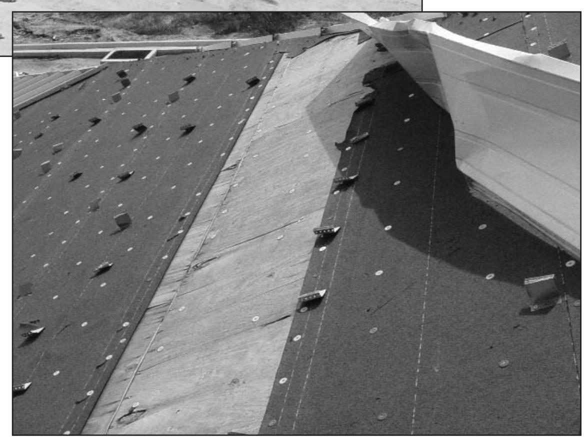
IRC helps North Americans build better, safer roofs to withstand hurricanes

For more than a decade, researchers at IRC have been contributing their expertise to help construction associations, roofing manufacturers, insurance companies and building owners better prepare themselves for the destructive forces of hurricanes through their research and participation in various investigative teams that study hurricane damage.

This past August, Dr. Bas Baskaran, of IRC's Building Envelope and Structure Program, was asked to come to Florida to study the effects of Hurricane Charley on roofing systems. Charley was a Category 4 storm that ravaged the state, causing 25 deaths and an estimated $11 billion (U.S.) in damages.

They found that over 70% of the damages were to houses, but that essential facilities such as hurricane shelters, hospitals, schools and fire stations were also affected to some degree.

Dr. Bas Baskaran points out the extensive roof damage as the result of a hurricane.



As part of a team assembled by RICOWI (see sidebar), and in cooperation with the Federal Emergency Management Agency (FEMA), following the devastation wrought by Hurricane Charley, Dr. Baskaran investigated damaged roofing systems in the area and helped document the key factors that contributed to the damage.

The WIP teams investigated over 100 commercial and 400 residential roofs. They found that over 70% of the damages were to houses, but that essential facilities such as hurricane shelters, hospitals, schools and fire stations were also affected to some degree. As well, the teams learned that failure to consider certain fundamental design principles, poor workmanship and inadequate roofing components all played a major role in these roofing failures. In addition, the teams collected data on roofs that had performed well in the hurricane for purposes of comparison.

This investigation was the first of its kind—the most comprehensive investigation ever of roofing in a hurricane-stricken area. And the findings from this investigation have helped validate IRC's own research.

For more information about the findings of the WIP teams, please contact Dr. Bas Baskaran at (613) 990-3616, fax (613) 998-6802, or e-mail bas.baskaran@nrc-cnrc.gc.ca.

In 1997 RICOWI (Roofing Committee on Weather Issues) established a wind investigation program (WIP) to document the field performance of roofs after a major wind event. Under the auspices of the U.S. Department of Energy (DOE), professionals from across North America were selected and trained to examine wind damage to roofing systems. Teams of experts have been in place since 1997, but until Hurricane Charley occurred, there had not been a storm that met the critical criterion for a wind speed of 95 mph, sustained for one minute or more when it makes landfall in a populated area.

Upcoming events

APRIL

20-24
2005 Forensic Engineering Symposium, New York, NY. http://www.asce.org/conferences/forensics05/

MAY

10
Workshop on Design Fires. National Research Council of Canada. Ottawa. http://irc.nrc-cnrc.gc.ca/fr/designfires workshop/index_e.html

11-13
Short Course Fire and Explosion Investigations. Carleton University. Ottawa. http://www.carleton.ca/~ghadjiso/

JUNE

7-9
4th International Symposium on Environmental Hydrology & 4th Regional Conference on Civil Engineering Tech., Cairo, Egypt. http://www.geocities.com/intsymp4_conf4/

8-12
10th Canadian Masonry Symposium. Banff, AB. www.ucalgary.ca/~tenthcms

12 and 13
Canadian Commission on Building and Fire Codes Meeting. Ottawa. Contact: John Archer at (613) 993-5569, e-mail john.archer@nrc-cnrc.gc.ca

28-29
Meeting of the CCBFC Executive Committee. Contact: John Archer at (613) 993-5569, e-mail john.archer@nrc-cnrc.gc.ca

JULY

12-15
International Conference on Computing in Civil Engineering 2005, Cancun, Mexico. http://www.asce.org/conferences/iccc2005/

AUGUST

17-19
17th Canadian Hydrotechnical Conference and Symposium Honouring Professor N. Rajaratnam, CSCE, Edmonton, AB. http://www.hydrotechnics.ca/hydro2005/index.htm

21-24
Pipelines 2005, Houston, TX. http://www.asce.org/conferences/pipelines2005/

SEPTEMBER

5-7
2005 Computing and Control for the Water Industry Conference, Exeter, UK. http://www.ex.ac.uk/ccwi2005/

18-21
DSS 2005, Conference and Exposition for Water Distribution and Plant Operations Professionals. AWWA, Tampa, FL. http://www.awwa.org/conferences/dss/call/

22-24
DFI 30th Annual Conference on Deep Foundations, Chicago, IL. http://www.dfi.org/

This calendar does not include all events scheduled to take place during this time frame. For a more complete listing, see the Web version of "Upcoming events" at http://irc.nrc-cnrc.gc.ca/events.html

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