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In this issue:

International Association for Wind Engineering

A Web-enabled cloud-based CFD Platform "Virtual Wind Tunnel"

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The complexity of multi-scale turbulence-structure interactions have thus far precluded a functional relationship between wind speed and its load effects on structures immersed in atmospheric boundary layer. Therefore, physical modeling of scale models of structures in boundary layer wind tunnels is the method of choice to study wind effects on structures. Recent advances in numerical schemes and escalating growth in computational resources have aided efforts in developing computational simulation of flow around structures using Computational Fluid Dynamics (CFD). In order to capture multiple-scale interactions and resolving small scale fluctuations, one faces major challenges that include both computation speed as well as memory to manipulate millions of pieces of information at grid points or control volume nodes. These challenges have limited the success of CFD in simulating real world scenarios. Despite challenges some groups around the world have made significant progress, especially in Japan where AIJ (Architectural Institute of Japan) now permits use of CFD in determining wind effects on structure with a caveat that it will be carried out under the direction of an expert.

CFD simulations are usually complicated, time-consuming, computational expensive, and require a good understanding of underlying computational schemes and the physics of flow. CFD solves non-linear Navier Stokes equations that describe fluid motions, where turbulence models can be employed to simplify mathematical modeling, using discretization methods to obtain the solutions and applying them to domains in time/space. Figure 1 is a CFD workflow that illustrates the overall process.

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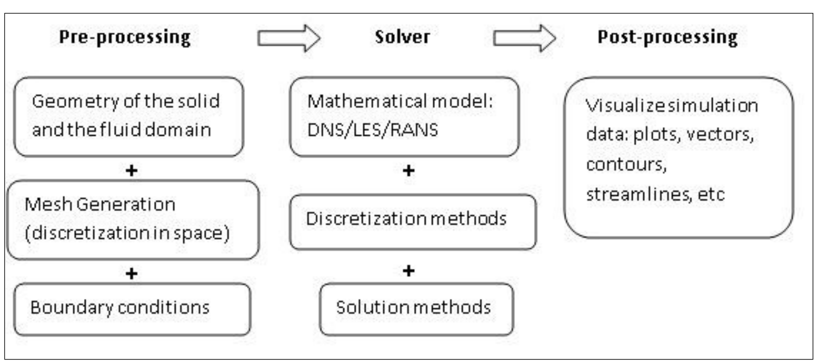

Figure 1. A typical CFD workflow

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These challenges impose a steep learning curve and have kept this venue of quantifying wind loads on structures closed for a majority of wind engineering researchers and practitioners. Two recent studies in which the authors served as a Co-PI, facilitated the development of a "Virtual Wind Tunnel" to help people not fully versed in the nuances of CFD be able to simulate wind-structure interactions and benefit from the emerging power of simulation driven technologies. Despite initial serious criticism of many CFD users concerning this effort that it is too complicated to be placed in the hands of novice, we are pleased to report that we have succeeded in the initial development and have removed "the fear" out of CFD that has haunted many users. We have successfully demonstrated that the concept though initially opposed by some experts is feasible as a group of student engineers, low-skill volunteers from Amazon Mechanical Turks, graduate students and post doctors were able to simulate flow with reliable results.

VWT is a user-friendly web-enabled CFD collaborative platform that does not require expertise of CFD simulation and extensive computer resources. It employs Gmsh (http://gmsh.info/) as the unstructured mesh generator and OpenFOAM (http://www.openfoam.com/) as the CFD simulator, and allows users to import various designs and run two dimensional wind simulations. The simulations are automatically sent to powerful cloud and/or grid based computing backend. Figure 2 shows the login screen and Figure 3 shows the prototypes of Community Designs and My Designs that illustrate the system.

User friendly features and various usages

To help create a new geometry easier, users can use SketchUp (http://www.sketchup.com/). In SkechUp users can either draw the design by themselves or download from its 3D warehouse where there are millions of models such as autos, aircrafts, buildings, including famous tall buildings like Burj Khlifa, World Trade Center, etc. Users can also create geometry from Template on the platform. With Template, users can create new design by specifying the height, width and control points, and the points can be segment endpoints or spine control points. Figure 4 shows an example. The feature of Template makes creating the geometry easier when users want to change the location of some control points, and it can be particularly useful for exploring shape optimization.

Once the geometry is created, mesh control should be set. Mesh generation is the most complex part of CFD simulations and it requires necessary experience, thus becomes a key problem for non-experienced CFD users. VWT makes mesh generation task easier. It only requires simple mesh control parameters input such as the distances to four sides of the fluid domain, boundary conditions, and grid sizes. Sub domains can be created to refine the mesh in specified regions. By following the solution control setting, inflow velocity, simulation time step and duration, kinematic viscosity, turbulence model, etc can be managed. Default values are automatically filled in on the setting page, which makes it easier for new comers in CFD users to start a simulation, it

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Figure 2. Virtual Wind Tunnel login screen

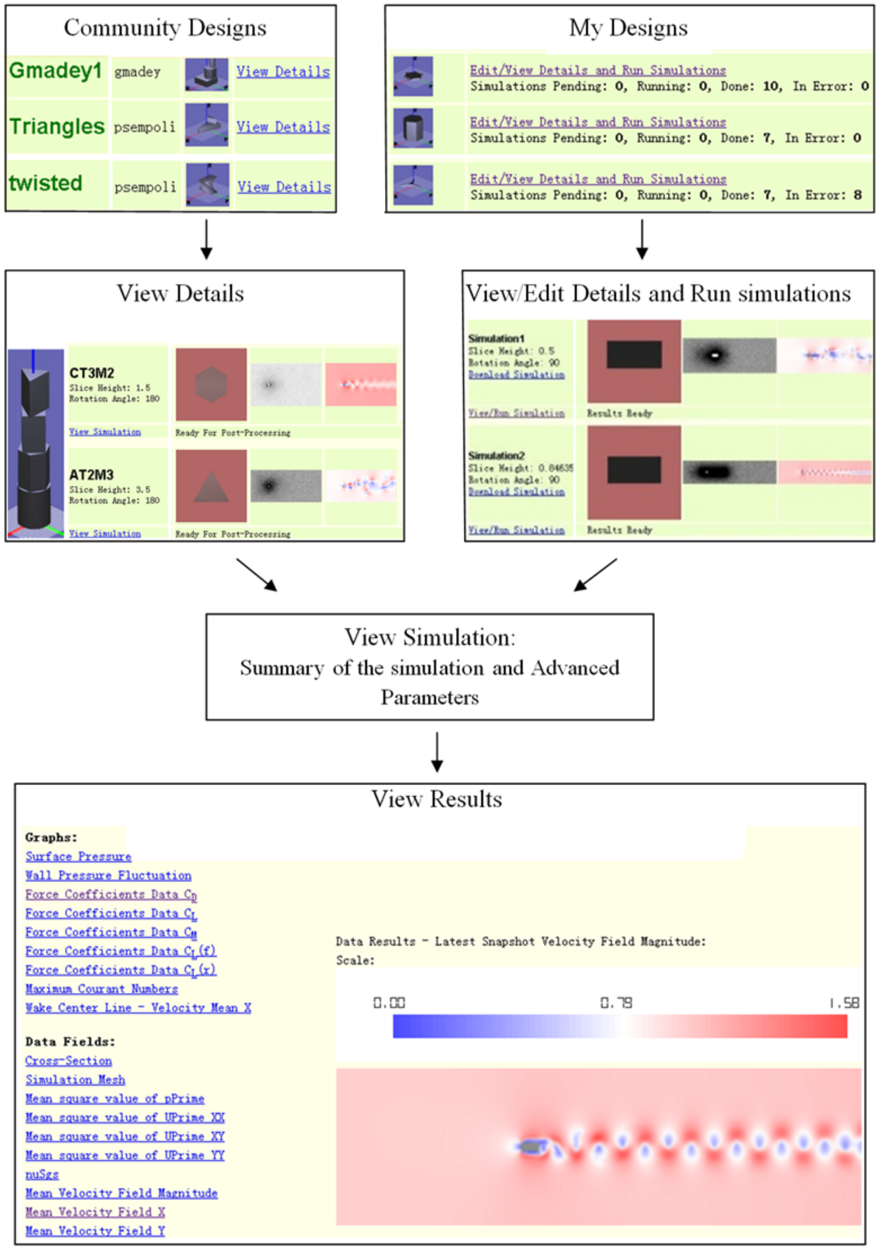

Figure 3. An illustration of Community Designs and My Designs

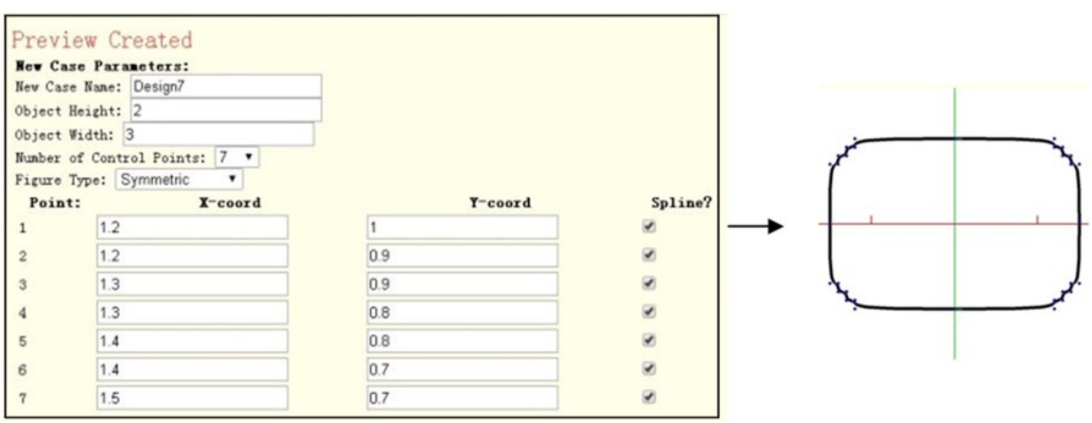

Figure 4. An example template for creating a new design

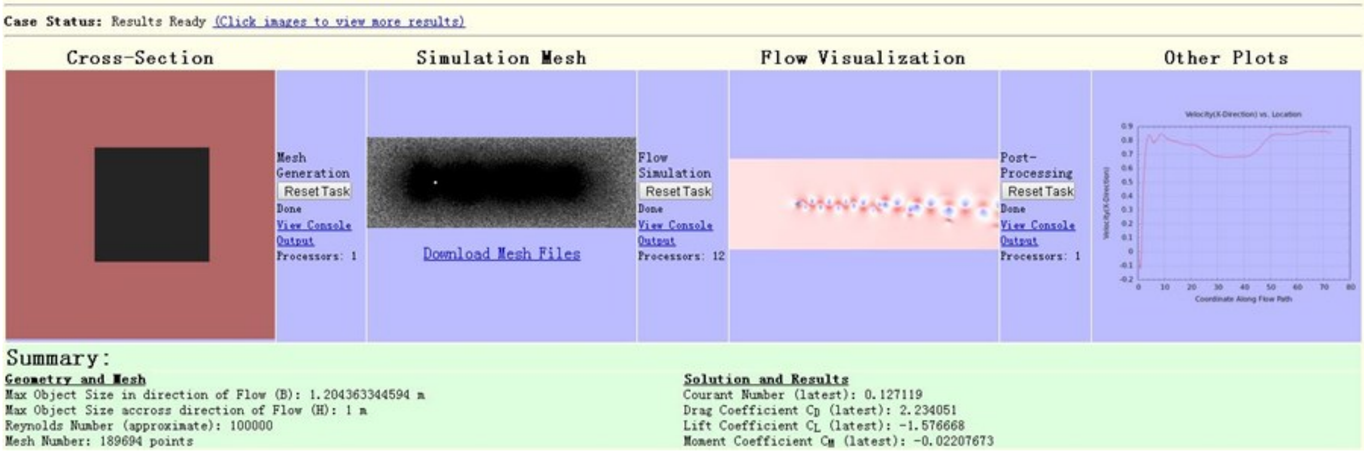

Figure 5. An example of a completed task

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is especially helpful for the most difficult while important part of mesh generation. The system gives suggestions to modify the settings when error occurs during the simulation. In terms of turbulence models, there are laminar flow model, S-A one equation model, k-epsilon model, Smagorinsky turbulence model (LES) and Dynamic One Equation model(LES) to choose from at this stage.

New cases can be duplicated from existing ones, which makes it convenient to set similar cases, this feature is very useful for parameter comparison which is widely used in CFD. The user receives an email once the simulation is completed, and results of plots and data of pressures, velocities, force coefficients, mean Reynolds stress are outputted automatically for further viewing and analysis. Users can also download the simulation which is OpenFOAM case files, as well as force coefficients data for further post-processing.

Users are also able to access the VWT portal through a console-based interface which is useful when using tools like Matlab, which makes it more convenient to run a vast amount of simulations that share similar parameters, as well as to analyze the output data.

VWT implements some of the ideas of collaborative software design in computational wind engineering, letting users edit structural geometries, compile geometries into usable models for simulation, perform wind simulations, evaluate results and then share and discuss their work with other users. This feature is an attractive feature that promotes a culture of collaborative approach towards complex problems and to empower those who are beginning in the field. This has the promise of building a virtual community of users, especially in the era of ubiquitous internet, to reach a new level of potential.

Those features make VWT helpful for different users, varying from CFD experts to untrained potential users with the aid of sufficiently comprehensive tutorials. Professional CFD users can employ VWT to get a quick and easy prediction and validation. Structural engineers without CFD background can run wind simulations to get better understanding of aerodynamics of a building or a bridge cross-section by utilizing a tutorial detailing how to reject flawed simulations, along with some suggested parameter settings on VWT. Untrained workers can also run simulations by taking advantage of a bank of preliminary analysis of complex data they can import from the platform. Investigations to examine the feasibility of using crowdsourcing for various complexities of technical tasks using VWT have been carried out, and it shows that crowd workers with no background in engineering could follow tutorials and come up with acceptable solutions (Staffelbach et al. 2014)

Examples

To complete a task on VWT, a user should create the design, generate the mesh and run the simulation. The long-running simulations are automatically sent to powerful backend computing platforms. Figure 5 shows a completed task sequence.

An example case to demonstrate validation and verification involving flow around various shaped prism cylinders is presented. Figure 6 shows a comparison of the drag coefficient of a square prism at various angles of attack. Table 1 shows the drag coefficient of various shapes studied for this report. Simulations are also compared to the available wind tunnel data

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and were found to be in a good agreement as shown both in Figure 6 and Table 1.

Concluding remarks

The NatHaz Modeling Laboratory in its tradition of introducing ever new frontiers in wind related cyber infrastructure, e.g., the Vortex-Winds, presents a web-enabled cloud-based CFD simulation platform, the "Virtual Wind Tunnel", which is developed to explore simulations of fluid flow around structures. This tool not only can be used by CFD experts but also by untrained individuals, as a user-friendly CFD simulator. Compared to traditional forms of CFD simulations, VWT requires less expertise and facilitates. It also provides the virtual community of users to work and share their simulations, which makes it possible for individual users to learn aerodynamic features from existing simulations done by others, as well as a group of users working on the same project can have independent case settings as well as cooperate with others by sharing their simulations and comments. This collaborative effort helps to enhance simulation quality that otherwise may not be possible if working in isolation.

It is envisaged that more advanced features like 3-D structures and aeroelastic effects can be developed based on this very modular work flow. It is anticipated that VWT may become a part of the NSF NHERI initiative's cyber infrastructure through its SimCenter /CI center for continued advances.

Acknowledgments

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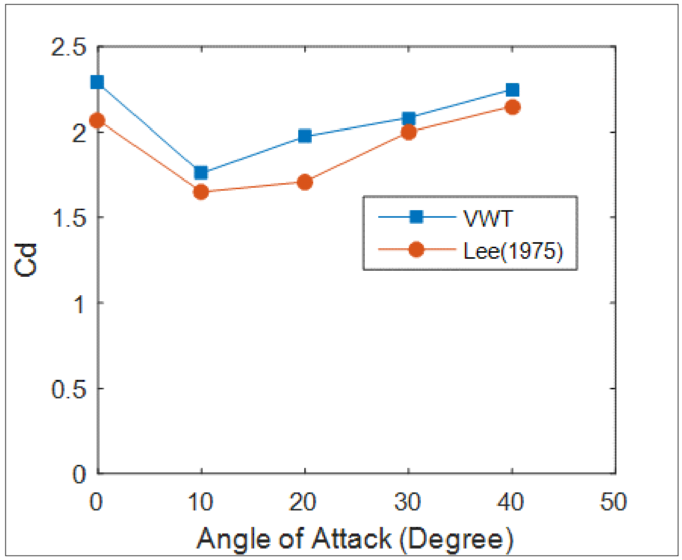

Figure 6. Drag coefficient of a square cylinder at various angles of attack

Table 1. Drag coefficient of various shapes

	VWT	References
Circular cylinder (Re=10e5) ○	1.30	1.2 (Wieselsberger , 1921)
Square cylinder □	2.29	2.19 (Bearman and Trueman, 1972)
Rectangular cylinder (Ratio=2) ▭	1.63	1.60 (Mozita, et al. 1988)
Flat plate perpendicular to flow ▯	2.03	2.13 (Fage and Johansen, 1927)

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CPP Named a 'Colorado Companies to Watch' Winner

2016 Colorado Companies to Watch Award Winners

CPP Wind Engineering & Air Quality Consultants has been named a Colorado Company to Watch, acknowledging the success, innovation, and influence of CPP as a growing company. Chosen from over 1,000 nominations, the 50 winning companies represent a broad range of industries and are recognized for their success and potential for growth, community involvement, and corporate culture.

"We are pleased to recognize CPP for their outstanding contribution in fueling the economic fire of Colorado. Thank you CPP Wind Engineering," says Sean Nohavec, Colorado Companies to Watch Board Chairman. "Second-stage companies are critical job creators, innovators, and drivers of our economy. Too often their incredible contributions to our state are overlooked. We are pleased to bring deserving recognition to these truly impactful organizations."

Colorado Companies to Watch is an awards program honoring second-stage companies headquartered in the state of Colorado. The organization works to recognize the driving economic forces in the state by focusing not merely on growth, but on the true impact and influence of an organization. The 400 companies that have been honored since the program's inception demonstrate high performance in the marketplace or exhibit innovative products or processes.

CPP, a long-time member of AWES, was co-founded in 1981 by Colorado State University professors Dr. Jack Cermak and Dr. Jon Peterka, renowned pioneers in the field of wind engineering. The Jack E. Cermak Medal, named for the CPP co-founder, was established by ASCE to recognize extraordinary career contributions to the field of wind engineering.

CPP's technical leaders have held key roles in the establishment and development of wind loading codes and wind tunnel testing methods throughout the A/E/C industry. The company's portfolio includes many unique and innovative structures around the world.

For more information on Colorado Companies to Watch, visit ColoradoCompaniestoWatch.org.

For more information on CPP Wind Engineering, visit www.cppwind.com.

CPP receives Colorado Companies to Watch Award

8th International Colloquium on Bluff Body Aerodynamics and Applications

The American Association for Wind Engineering (AAWE) recently sponsored the 8th International Colloquium on Bluff Body Aerodynamics and Applications (BBAA VIII), which was hosted by Northeastern University, Boston, Massachusetts, on June 7-11, 2016. The event was co-chaired by Luca Caracoglia of Northeastern University (NEU) and Chris Letchford of Rensselaer Polytechnic Institute (RPI). Held every 4 years, this colloquium is one of the main conferences promoted by the International Association of Wind Engineering (IAWE) and is only the second time the colloquium was held in the United States. As an effort to continue the tradition, the colloquium followed in the footsteps of the very successful meetings in Milan 2008 and Shanghai 2012.

The event was held on the Boston campus of NEU. The local organizing committee included members of the NEU's College of Engineering and the Department of Civil and Environmental Engineering. The success of the event is the results of a group effort, composed of Ms. Anne – Carina Kelly (NEU) and her team for the logistics, collaborators, graduate students, volunteers and helpers. The event attracted more than 240 total participants, of whom 80 were students (including presenters and volunteers), over the three days of the technical sessions. Attendees were from 24 different countries around the world. All the three regions of the wind engineering community were represented at this event. Figure 1 illustrates the BBAA-VIII group picture taken on the first day of the colloquium.

The organizers were honored to receive many excellent quality papers for the proceedings of the colloquium. The committee received 250 initial submissions of four-page extended abstracts, which were subjected to a thorough review process before acceptance, carried out by the 130 members of an international Scientific Committee of experts. The authors of all the accepted extended abstracts were asked to prepare and submit full papers. The final program included 3 keynote lectures, 186 oral presentations and 19 poster presentations over three days. Oral presentations were organized in three parallel technical sessions, subdivided by theme or topic.

Recent technical accomplishments in wind engineering and wind energy were discussed. The topics included: advances in the analysis of air flows and fluid-structure interaction (FSI) around bluff bodies; enhanced experimental facilities for boundary layer, tornadic and full-scale wind tunnel testing; innovative computational fluid dynamics (CFD) methodologies; advances in the analysis and modeling of slender structures (e.g., buildings and bridges); advances in the analysis of flows and FSI for wind energy systems and wind turbines. New and emerging topics, such as performance-based wind engineering (PBWE), were also part of the program. The final count of the presentations (and papers) is illustrated in Figure 2.

Three excellent keynote lectures were delivered by Professor Emmanuel de Langre, Ecole Polytechnique of Paris, France (on "Plant-wind interactions, from small leaves to canopies"), Professor You-Lin Xu, Hong Kong Polytechnic University (on "Aerodynamics and structural health monitoring of long-span cable-supported bridges") and Professor Michael Amitay of RPI (on "Active flow control and its application in fluid systems").

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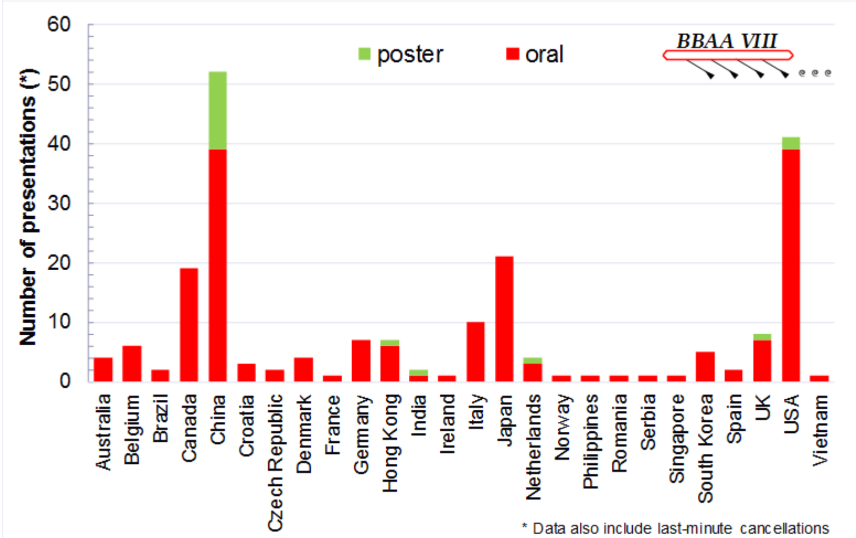
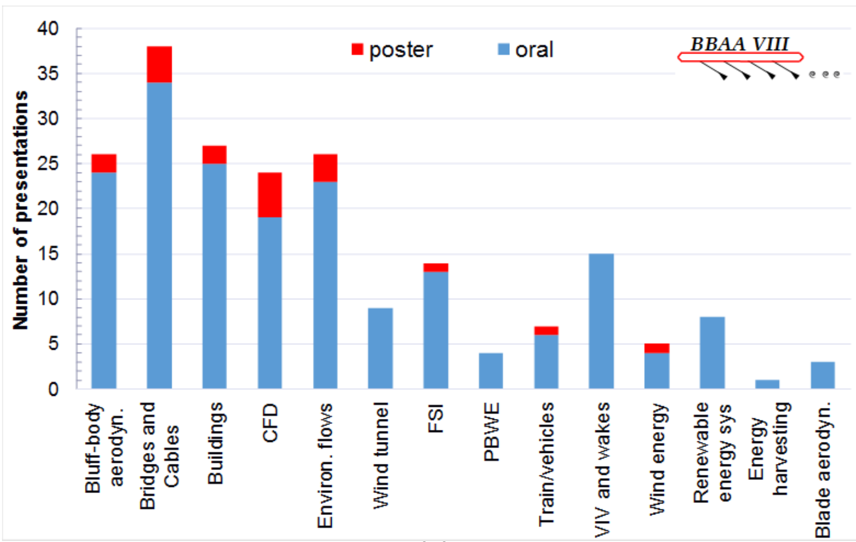
Figure 1. Group picture of BBAA-VIII participants



(a)



(b)

Figure 2. Number of presentations (oral and poster) at BBAA VIII, subdivided by: (a) country of the first author, (b) topic classification.

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Several sessions were well attended and provided new insights on the state-of-the-art in the various disciplines related to bluff bodies and aerodynamic loading. The main events of the conference included keynote lectures, parallel technical sessions, poster sessions during conference breaks and lunches. The colloquium banquet was held at the "Top of the Hub" restaurant on the 50th floor of the Prudential Tower, located in the Back bay of Boston; the banquet was the signature event of the colloquium. Some photos, documenting the various stages of the BBAA VIII, can be found in Figure 3 (technical discussions continuing during the breaks), Figure 4 (conference banquet) and Figure 5 (conference co-chairmen thanking the plenary speakers).

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Figure 3. Technical discussions continuing during one of the breaks

Figure 4. Conference banquet: top row: A. Kareem, J. Holmes, J. Náprstek, J. F. Hajjar (NEU), Ms. Letchford, K. C. S. Kwok; second row: E. English, D. Lander, C. Baker, C. Letchford, D. Prevatt and M. Sterling.

Figure 5. L. Caracoglia (right) and C. Letchford (left) recognizing two of the plenary speakers of BBAA VIII, Profs. E. de Langre (center right) and M. Amitay (center left)

(Continued from page 8)

The 2016 IAWE Award Ceremony was also part of BBAA-VIII. The IAWE recognized two outstanding members of the research community for their contributions to the discipline of wind engineering. The senior IAWE award (Davenport Medal) was conferred to Prof. Yukio Tamura of Tokyo Polytechnic University (Japan); the junior IAWE award was presented to Prof. Tim K. T. Tse of Hong Kong University of Science and Technology (China).

The organizers were also grateful to the BBAA-VIII sponsors, who provided funds to allow 34 graduate students from the three IAWE regions to attend and present their work. As part of this event and because of the support provided by IAWE, AAWE and several industry sponsors, the organizing committee awarded 34 travel fellowships to graduate students from several countries, based on merit. The sponsors of the travel fellowships included: RWDI of Canada, CPP Wind Engineering, FM Gobal, the Insurance Institute for Business and Home Safety, Simpson Gumpertz and Heger, the University of Florida and Western University in Canada. More information, details and pictures about the BBAA-VIII Colloquium may also be found on the website: http://www.northeastern.edu/bbaa8/.

Texas Tech's Debris Impact Facility accredited by A2LA

The National Wind Institute's Debris Impact Facility (DIF) at Texas Tech University has received its ISO/IEC 17025 accreditation from the American Association for Laboratory Accreditation (A2LA).

The internationally recognized accreditation comes after a thorough assessment of the quality management system, the traceability of measurements and calibrations to national standards, and the competence of the National Wind Institute's Debris Impact Facility.

Larry Tanner, manager of the DIF and a research assistant professor for the National Wind Institute (NWI), said the facility now is accredited as an ISO/IEC 17-25 laboratory that provides impact testing services for national and international clients.

You can read more at: http://today.ttu.edu/posts/2016/06/nwi-accreditation

Upcoming Wind Engineering conferences

- **4th American Association for Wind Engineering Workshop**
  Miami, Florida
  August 14 - 16, 2016
  http://4aawe.fiu.edu/index.htm
- **UK Wind Engineering Society 12th Biennial Conference**
  Nottingham, England
  September 5 - 7, 2016
  http://www.wes2016.co.uk
- **13th Americas Conference on Wind Engineering**
  Gainesville, Florida
  May 21 - 24, 2017
- **7th European and African Conference on Wind Engineering**
  Liège, Belgium
  July 3 - 6 2017.
- **9th Asia-Pacific Conference on Wind Engineering**
  Auckland, New Zealand
  December 3 - 8, 2017

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