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# THE WIND ENGINEER

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## Full-Scale Investigation of Wind-Induced Vibration of Mast-Arm Traffic Signal Structures

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In New York State, recently designed and installed mast-arm traffic signal structures longer than 14 m do not meet the fatigue provisions of the updated AASHTO code. There is concern that these relatively new structures will not provide long-term reliable and safe service. For this reason, the New York State Department of Transportation (NYSDOT) commissioned Research Project No. C-10-07, "Determining Remaining Fatigue Life of In-Situ Mast-Arm Traffic Signal Supports". This project is a collaborative effort between Rensselaer and NYSDOT to conduct a thorough investigation (through full-scale experiment) of the response of a given, in-situ mast-arm traffic signal structure to actual, observed wind conditions. Harry White is the NYSDOT project manager, Professors Christopher Letchford and Michael O'Rourke are Co-Principal Investigators and Michelle Riedman is the Graduate Student Researcher. The results from this full-scale experiment will allow for a projected 'safe life' of this given structure to be calculated and will form the bases for the development of a general methodology that can be used to assess the remaining fatigue life of cantilevered mast-arm traffic signal structures throughout New York State.

Vortex shedding is an observed phenomenon that is responsible for inducing large vertical vibrations of mast-arm traffic signal structures. When wind flows past the mast arm of the structure, low-pressure vortices are shed on alternating sides of the arm causing the mast arm to vibrate in a cross-wind or vertical response.

If the frequency at which the vortices are shed (which is a function of both the wind speed as well as the diameter of the mast arm) matches the natural frequency of the structure, a resonant response is created and vibrations with high amplitudes can occur. In some cases, the vibrations of the body itself may enhance the strength of the vortices and may also alter the vortex shedding frequency tending to couple it with the natural frequency of the structure and creating a phenomenon known as 'lock-in'. These vibrations cause structural stresses and strains to occur in a cyclical fashion which can lead to fatigue of the structure, and in some cases full collapse.

An in-situ mast-arm traffic signal structure with a 25 meter long mast-arm located in Malta, NY is being used for the full-scale experiment. An ultrasonic anemometer and two 3-component accelerometers were installed on the structure and data is currently being recorded at intervals of 23Hz through a data acquisition system.

While installing the equipment, pluck tests were conducted in order to determine the dynamic properties of the structure. To conduct these pluck tests, the free end of the mast arm was manually excited by a person from the research team with access via a boom lift and then let go so that the structure entered into free vibration. These results were compared with the finite element models that had been developed prior to the full scale tests. Knowing the fundamental frequency of the structure allowed for the calculation of the wind speed predicted to cause the resonant response of the structure through a vortex shedding phenomenon.

Turbulence in the approach flow is known to affect the cohesiveness of vortex shedding. Preliminary results from this full-scale experiment indicate that the surrounding terrain conditions, which affect the turbulence intensity of the wind, greatly influence both the likelihood of occurrence of long-lasting, high-amplitude vibrations and whether fatigue is likely to lead to a reduced service life of the structure.

International Association for Wind Engineering

# Behaviour of an Aeroelastic Transmission Line Model in Yawed Wind

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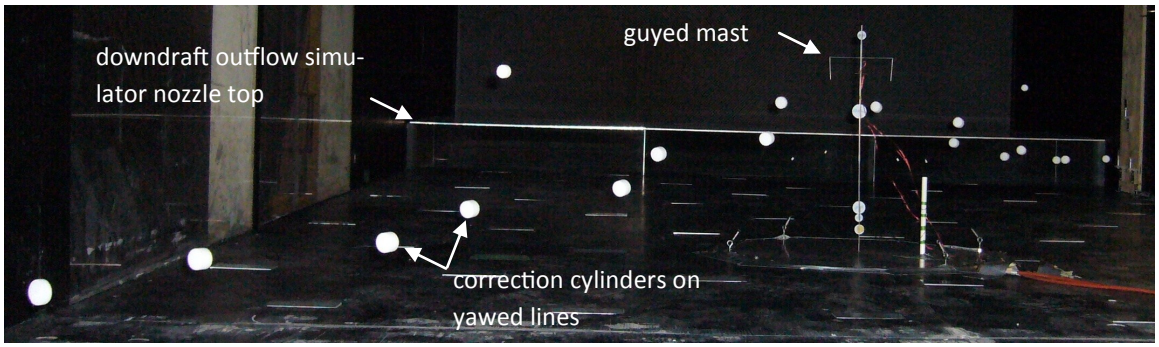
Designing overhead power transmission lines to withstand downdraft outflows is a challenging problem due to limited field observations and the variations in the characteristics of the wind load and structure. Progress has been made on idealised versions of the problem and the current state-of-the-art couples Computational Fluid Dynamics simulation of downdraft outflows with Finite Element simulation of structural response. Significant work remains to be done to validate the comprehensive predictions now available from these numerical simulation tools.

A single-span aeroelastic model of power transmission lines suspended from a guyed mast was subjected to two types of wind loading in a single experimental test facility. One conductor line was upstream of the tower and another was downstream of the tower. In addition to the zero yaw case (i.e. normal-to-line wind loading), oblique yaw angles of 30° and 60° (see figure below) were studied. Line tensions and mast bending moments were measured. For the studied yaw angles, line tension behaved quasi-statically for the boundary layer wind loading. The upstream conductor tension was generally double the downstream conductor tension for the downdraft outflow wind loading. Line tensions consistently increased in magnitude and decreased in coherence and periodicity as yaw angle of the downdraft outflow increased. The downdraft outflow simulator with aeroelastic model yielded remarkably consistent and robust measurements over an ensemble of fifty trials at each tested yaw angle.




*Yawed line system in the downburst outflow simulator (this photograph was taken looking upstream at the guyed mast at the test section mid-span with the yawed lines approaching the camera towards the left of the image and the flow nozzle in the background)*

## 12th Americas Conference on Wind Engineering Successfully Held

The 12th Americas Conference on Wind Engineering (12ACWE) was held June 16 – 20, 2012 in Seattle, Washington. The Americas Conference for Wind Engineering is held under the auspices of the American Association for Wind Engineering (AAWE), which is one of three sub-organizations of the International Association for Wind Engineering (IAWE). A diverse group, from more than 30 countries attended the conference and presented their research during 26 technical session comprising approximately 130 papers and 35 posters. These technical sessions were conducted over a three day period and incorporated a broad range of wind engineering topics, including ways to keep weather hazards from becoming disasters as well as way to better harness wind energy. Three keynote speakers headlined the conference's start at the beginning of each day of technical sessions: Mr. Ronald T. Eguchi, president and CEO of ImageCat, Inc.; Dr. Cliff Mass, professor of atmospheric sciences at the University of Washington; and Dr. David Rosowsky, professor of civil and environmental engineering and dean of engineering at Rensselaer Polytechnic Institute.

Besides the traditional wind engineering topics of aerodynamic loads on tall buildings and bridges, there was renewed emphasis on the effects on tornadoes on buildings. Several sessions were devoted to tornadoes and their effects on structures of all types. Another theme which emerged was the topic of renewable energy, and encompassed both roof mounted photo-voltaic panels or wind turbines. The new and organizing research which was presented on these topics is directly relevant to the further advancement of renewable energy projects in the state. The issue of wind climate, climate change and wind extremes were also discussed. Final conference proceedings, including full papers, were published electronically; selected papers will be published in a special issue of the Journal of Wind Engineering and Industrial Aerodynamics.

A boat cruise for a salmon dinner at Tillicum Village served as the venue for IAWE and AAWE award presentations. AAWE awards were presented for best journal papers. (*Editor's Note*: For more details on awards, see page 3.)

The conference capped off with a technical tour to the birthplace of modern wind engineering, The Tacoma Narrows Bridges. Another behind the scenes post-conference technical tour to the Boeing factory was also organized.

# President's Corner

Greetings! I trust you have had a productive and refreshing summer. In this newsletter, we begin our first profile of student research. I was very excited by the fact that we had 70 students attend the 12th Americas Conference on Wind Engineering in Seattle this past June. Over 30 of these students were awarded travel grants from the National Science Foundation and the International Association for Wind Engineering. We have asked these students to write brief abstracts of their conference presentations so that the membership can become familiar with the remarkable work these young people are producing; indeed, these are the engineers and researchers who will become the future of our discipline.

We trust you will enjoy these brief articles. If you wish to see their entire papers, please log-on to the AAWE website, where you can find the proceedings from our past conferences.

Rather than producing a long newsletter 2 – 3 times a year, we are re-formatting the newsletter to be shorter, but delivered to you more often. Over the next year we expect to have a monthly newsletter, highlighting the student research. Thanks to those who have already sent us papers. If you wish to contribute an article, please send Prof. Hector Cruzado (hcruzado@pupr.edu) or me (gakopp@uwo.ca) a brief note.

This summer also saw our election for President-Elect and the 3 open positions on the Board of Directors. I am pleased to announce that Prof. Chris Letchford of RPI is President-Elect. In January 2015, he will take over as President for a two year term through the end of 2016. In addition, Mr. Bill Coulbourne, Prof. David Prevatt and Prof. John Schroeder were elected to 4 year terms on the Board of Directors, with terms ending in December 2016. They join our ongoing Directors, Mr. Steve Camposano, Dr. Anne Cope and Prof. Dorothy Reed, whose terms continue until the end of 2014. Prof Steve Cai continues his excellent work as treasurer. The changes to our bylaws also passed; you can also find these posted on the AAWE website. I would like to thank Drs. Anne Cope, Hector Cruzado Leighton Cochran, and Prof. Partha Sarkar for their support in conducting the election and counting the ballots.

Finally, I would like to announce that Prof. Forrest Masters is the Chair of the 13th Americas Conference on Wind Engineering, which will be held in beautiful St. Augustine, Florida in 2017.

The Board continues to be interested in ways we can make AAWE more relevant to you and to enhance the implementation of our mission "to promote and disseminate technical information in the research community". If you have any questions or comments about AAWE, please do not hesitate to contact me. I would love to hear from you.

With warm regards,

Greg Kopp
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# AAWE Awards for 2013

During the recent Americas Conference on Wind Engineering in Seattle, WA, the association presented five awards: the Richard Marshall Award, the Robert Scanlan Award, the Michael Gaus Distinguished Service Award, the Industry Innovation Award, and the Best Paper Award. Due to a tie, the Best Paper Award was presented to two groups. Thanks are extended to those who served on individual review committees and to the AAWE members who nominated fabulous candidates for all of the awards. Congratulations to the following award recipients:

- Murray Morrison, presented the Richard Marshall Award in recognition of his contributions to wind engineering for the best doctoral thesis related to experimental methods or field investigations.
- Eri Gavanski, presented the Robert Scanlan Award in recognition of her contributions to wind engineering for best doctoral thesis related to theoretical advances in the mechanics of wind-structure interaction.
- Leighton Cochran, presented the Michael Gaus Distinguished Service Award in recognition of his contributions to wind engineering for involvement in AAWE activities, research, consulting, and outreach.
- Peter Irwin, presented the Industry Innovation Award in recognition of his many contributions to the practice of wind engineering, including the design of the Burj Khalifa.
- Leighton Cochran and Russ Derickson, presented the Best Paper Award in recognition of their contributions to wind engineering for the journal paper titled "A physical modeler's view of Computational Wind Engineering."
- Michael Grayson, WeiChiang Pang and Scott Schiff presented the Best Paper Award in recognition of their contributions to wind engineering for the journal paper titled "Three-dimensional probabilistic wind-borne debris trajectory model for building envelope impact risk assessment."

The Best Paper Award is a recurring annual award, so please start thinking now about papers that will be published in 2013 for possible submission for the next opportunity to present this award. Nominations for the next Best Paper Award are due before January 31, 2014. Please send all nominations to the AAWE Awards Committee Chair, Anne Cope at acope@ibhs.org.

**American Association for Wind Engineering**

**Established in 1966**

A professional organization dedicated to the advancement of the science and practice of Wind Engineering and the solution of national Wind Engineering problems through transfer of new knowledge into practice.

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