Wind Engineering Joint Usage/Research Center
FY2021 Research Result Report

Research Field: Wind Hazard Mitigation
Research Year: FY2021
Research Number: 21213003
Research Theme: Effects of environmental parameters on pressure measurement via tubing systems and the structural response of a building: Experimental study

Representative Researcher: DongHun Yeo

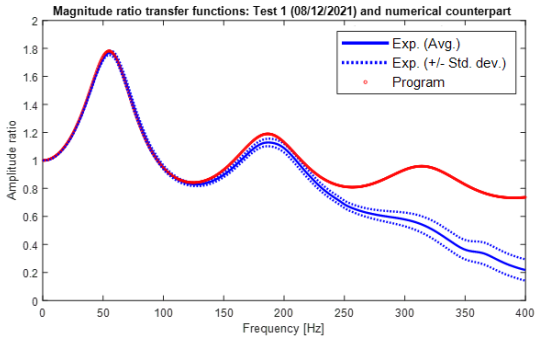
Budget [FY2021]: 300,000. Yen

*There is no limitation of the number of pages of this report.
*Figures can be included to the report and they can also be colored.
*Submitted reports will be uploaded to the JURC Homepage.

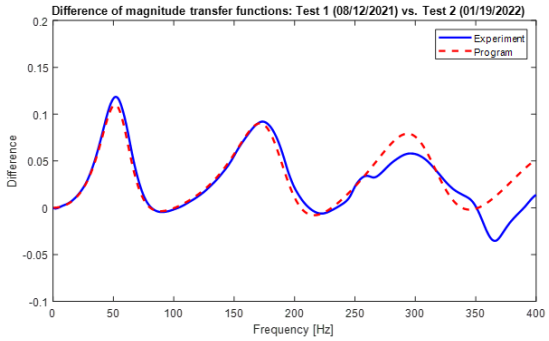
1. Research Aim
   To develop an approach to correcting experimental tubing response distorted by environmental conditions for improvement of accuracy pressure measurements

2. Research Method
   Developed a calibration approach to the estimation of the influence of environmental conditions on tubing response in pressure measurement experiments, using a NIST-developed numerical calibration program

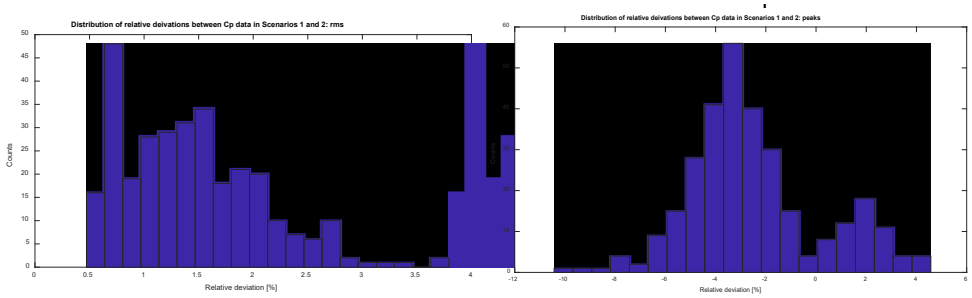
3. Research Results
   - Numerical prediction of tubing response was validated against the experimental measurements. Effects of environmental changes on tubing response were successfully estimated at up to ~ 200 Hz by numerical calculations



   - A calibration approach was developed for estimating experimental tubing response in any environmental condition using the numerical program.



- A case study showed that dynamic pressure calibration ignoring environmental conditions can result in errors of standard deviations and peaks of pressures up to ~4 % and ~10 %, respectively, especially on side and leeward walls of a building



4. Published Paper etc.

- Preparation for a technical article (authors: DongHun Yeo and Yong Chul Kim) to be submitted to Journal of Wind Engineering and Industrial Aerodynamics

[Presentations at academic societies]

1. Presentation to research staff at NIST

5. Research Group

- Representative Researcher: DongHun Yeo (NIST)
- Collaborate Researchers: Yong Chul Kim (TPU)

6. Abstract (half page)

Accurate measurement of pressures on structures in wind tunnel testing is critical for reliably estimating design wind loads. Owing to space limitation within models used in wind tunnel tests, a tubing system is generally employed to connect the pressure taps on the model to pressure sensors, which can result in significantly distorted fluctuating pressure measurements. To correct the measured dynamic pressures, current practice of the dynamic pressure calibration typically accounts for effects of dimensions of tubes in a given environmental condition (atmospheric pressure, ambient temperature), but neglects those of change in environmental conditions that can be significantly different between measurement times of tubing response and pressures on a building model.

To investigate the effect of environmental conditions on pressures measured via a tubing system, we performed tubing response measurements in two environmental conditions: (i) an atmospheric pressure of 100,400 Pa and a temperature of 29 °C and (ii) 100,995 Pa and 13 °C. Also, wind tunnel testing was carried out to measure pressures on a high-rise building in the first environmental condition. We validated a NIST-developed numerical calibration algorithm against the experimental data and developed a calibration procedure to estimate the influence of environmental conditions on tubing response in pressure measurement experiments, using the numerical calibration algorithm. Through this procedure, the tubing response in any environmental conditions can be estimated using supplemental numerical calculations once experimental tubing response is measured in a given condition.

Results from a case study show that dynamic pressure calibration ignoring environmental conditions can result in errors of the standard deviations and the peaks of pressures up to 4 % and as much as 10% for negative peaks and 5 % for positive peaks, respectively, especially on side and leeward walls of a building. The calibration procedure developed in this study can improve accuracy in pressure measurements via a tubing system, especially when tubing response and pressures are measured in different environmental conditions.

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This study validated a NIST-developed numerical dynamic pressure calibration algorithm against experimental data and developed a dynamic pressure calibration approach to estimate the influence of environmental conditions on experimental tubing response in pressure measurement experiments, using the numerical calibration algorithm.

A case study used two environmental conditions: (i) Scenario 1 - a high atmospheric pressure of 105,000 Pa and a low temperature of 5 °C in a sunny winter day and (ii) scenario 2 - an low atmospheric pressure of 95,000 Pa and a high temperature of 30 °C in a cloudy summer day. Their tubing response functions from the numerical algorithm are shown in Fig. 1.

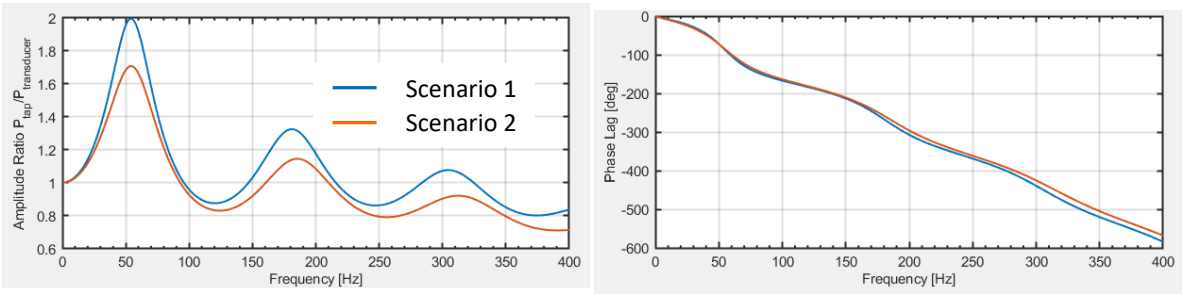

Fig. 1. Transfer functions under two environmental condition scenarios.

When an appropriate environmental condition is not used in the dynamic calibration procedure (e.g., calibration of pressures measured in Scenario 1 using tubing response measured in Scenario 2), this case study shows dynamic pressure calibration ignoring environmental conditions can result in errors of the standard deviations and the peaks of pressures up to 4 % and as much as 10% for negative peaks and 5 % for positive peaks, respectively, especially on side and leeward walls of a building. The calibration procedure developed in this study can improve accuracy in pressure measurements via a tubing system, especially when tubing response and pressures are measured in different environmental conditions.

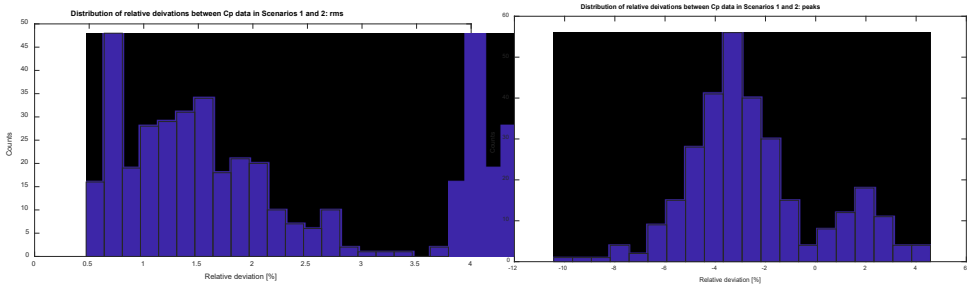

Fig. 2. Distributions of relative errors of rms and peak pressure coefficients