Development of New VMS Drag Coefficients

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Research Background

Variable Message Signs (VMS) are becoming an integral part of transportation infrastructure on U.S. interstates and highways. VMS structures are vital in ensuring the safety of motorists by relaying messages concerning potential road hazards such as fog, traffic congestion, highway construction, and lane closures. These sign structures are larger and heavier than typical flat panel signs, and thus behave differently when subjected to wind loads. The design of sign structures for wind drag is outlined in the AASHTO *Supports Specifications*. In reference to the design drag coefficient for VMS structures, the *Specifications* state that "A value of **1.7** is suggested for Variable Message Signs (VMS) *until research efforts can provide precise drag coefficients.*"

Research Objective

The overall objective of this research is to **develop accurate drag coefficients** for VMS structures for incorporation into the AASHTO *Supports Specifications* to **promote safer and more economical designs.** The research tasks required to accomplish this objective are:

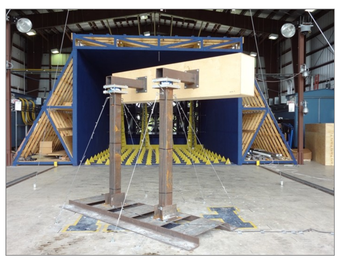
1. Wall of Wind testing at FIU to develop preliminary drag coefficients.
2. Experimental study of existing VMS structure to collect time history wind loading and stress response data.
3. Finite Element Modeling at UAB to compare the FIU and AASHTO drag coefficients with the experimental data, and to investigate the potential of member size reduction.

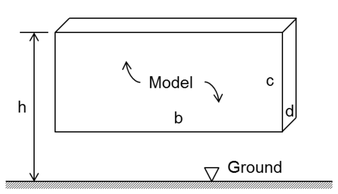
Impact of Research

This research will impact the engineering design community on a national scale by generating the following outcomes:

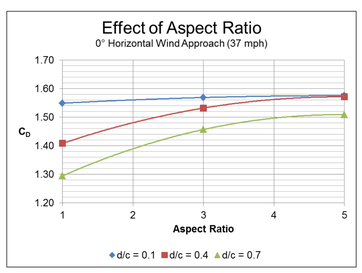
- Precise drag coefficients for Variable Message Signs (VMS) which account for the size and shape of the VMS.
- Potential size reduction of support members due to lower design stresses.
- National design code changes through modification of the AASHTO *Supports Specifications*.
- VMS structure designs which increase the safety and cost savings of U.S. highway infrastructure.

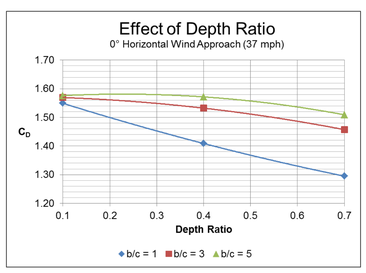
Wall of Wind Testing at FIU





- Aspect Ratio = b/c
- Depth Ratio = d/c

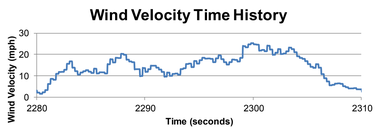


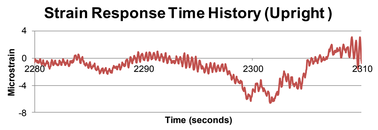


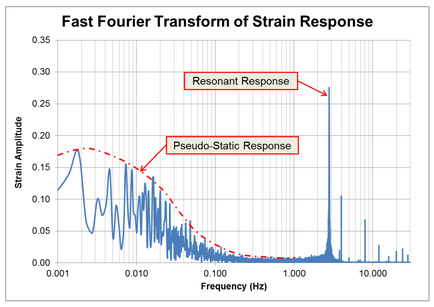
Experimental Study of VMS in Alabaster, AL

ALDOT collected time history data for the Alabaster VMS during fatigue level wind events. This data included the following:

- Wind velocity and direction *(measured using Anemometers)*
- Strain response in critical members *(measured using strain gauges)*
- Modal accelerations *(measured using accelerometers)*

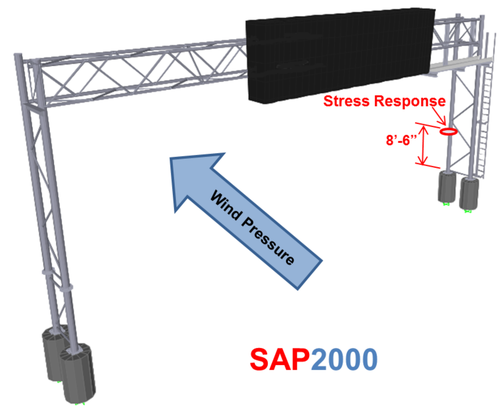






The Alabaster VMS structure experienced two main types of strain response under the time history wind loading: a **pseudo-static response** due to the wind gust frequency, and a **resonant response** due to the vibration of the structure about its own natural frequency. *Only the pseudo-static response was analyzed when evaluating drag coefficients.*

Finite Element Modeling at UAB



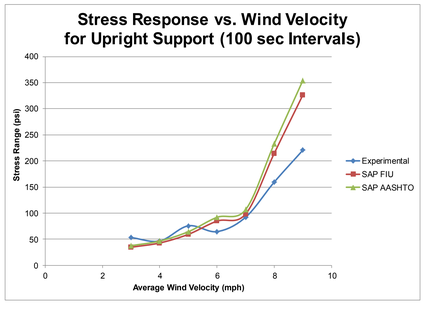
Time history dynamic wind loading from the Alabaster VMS was applied to the SAP2000 model using the following drag coefficients:

- FIU C_d = 1.54
- AASHTO C_d = 1.7

$$P = \frac{1}{2}\rho V^2 C_d \quad (psf)$$

The pseudo-static stress response was recorded in 100 second intervals at the location of the strain gauges. All resonant stress responses were filtered out.

$$\sigma = \frac{P}{A} + \frac{Mc}{I} \quad (psi)$$



FEM Conclusions:

- The FIU and AASHTO drag coefficients appear to be conservative when compared to the Alabaster VMS experimental data.
- Using the FIU drag coefficient for VMS structures will result in lower design stresses for support members.