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Full-Scale Wall of Wind Testing of Variable Message Signs (VMS) Structures to Develop Drag Coefficients for AASHTO Supports Specifications

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Introduction

- Variable Message Signs
  - Programmable
  - Real time advisories
    - Inclement weather
    - Traffic accidents/congestion
    - Construction
    - Public service announcements
  - Support structure varies
  - Larger 3D profile
  - Weigh > 4000 lbs
  - Vulnerable to fatigue and premature failure

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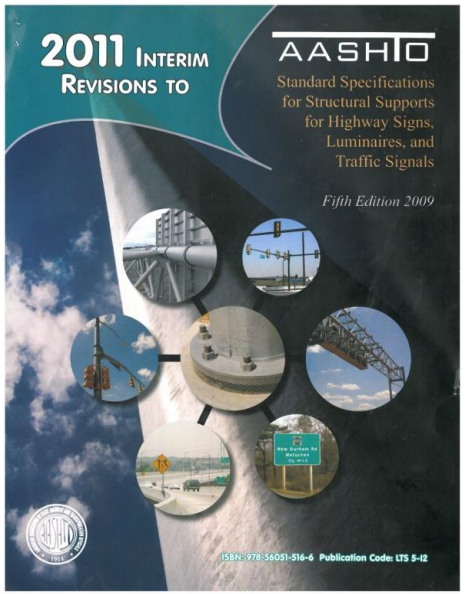
Problem Statement

- AASHTO (5th edition - 2009)
  - Provisions for Extreme Event and Fatigue
  - Wind drag effect can vary with wind speed
    - Structure geometry
    - Wind approach direction
    - Free stream turbulence
  - Extreme event wind loads
    - High mean annual winds speeds
      - May not ensure conservative design
    - Low mean annual wind speeds
      - Overly conservative for fatigue



AASHTO Standard Specification for Structural Supports for Highway signs, luminaires, and Traffic Signals

Using the same C_D for strength and fatigue can produce inefficient designs

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Project Objective

- Wind drag coefficients table in *Supports Specifications* (Table 3-6): "A value of 1.7 is suggested for Variable Message Signs (VMS) until research efforts can provide precise drag coefficients.“

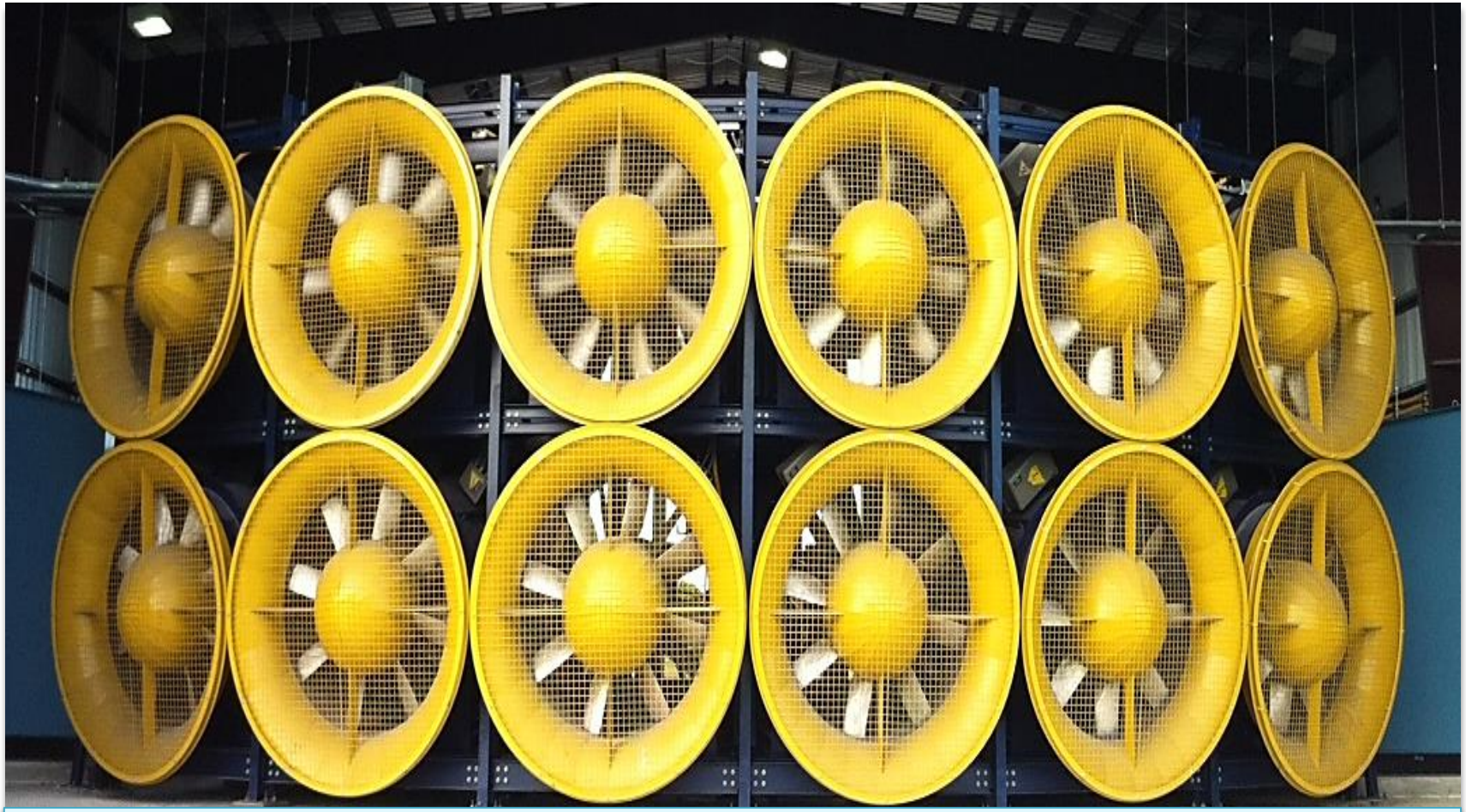
- ***The proposed research will address this issue by providing accurate drag coefficients for VMS signs, which can be used to provide a better estimate of the wind-induced loads on the VMS structures.***

Research Tasks

This Project will include:

- Extensive literature review,
- Investigation of industry standards,
- Large scale experimental testing in the Wall of Wind
- In-depth analysis of obtained data
- Formulation of drag coefficient recommendations for incorporation into AASHTO specifications.

Experimental Procedure



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Experimental Procedure

- Phase I Testing (September 2012 - completed)
  - Fatigue level winds (45 mph)
    - Tare Test (1 model, 2 tests)
    - Validation Tests (1 model, 2 tests)
    - Free Stream Wind (no model, 1 test)
    - Fatigue Level Drag Coefficients (9 models, 18 tests)

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Experimental Procedure

- Phase II Testing (Spring 2013)
  - Extreme Event Winds (150 mph)
    - Tare Test (1 model, 2 tests)
    - Validation Tests (1 model, 2 tests)
    - Free Stream Wind (no model, 1 test)
    - Extreme Event Drag Coefficients (9 models, 18 tests)
    - Corner Mitigation (1 model, 2 tests)
    - Wind Driven Rain (1 model, 2 tests)
    - Galloping Potential (1 model, 2 tests)
    - Blockage Effect (2 models, 4 tests)

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Experimental Setup

- Drag Coefficients
  - Fatigue Level Winds
    - Wind speed: 45 mph
    - Non-turbulent flow (I ≈ 4.5%)
    - Wind direction 0° and 45°
  - Extreme Event Winds
    - Wind speed: 150 mph
    - Open terrain boundary layer (ASCE Exposure Category C)
    - Wind direction 0° and 45°

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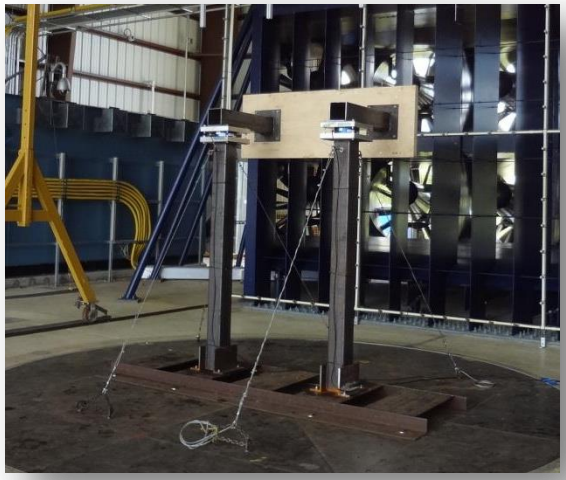
Experimental Setup

- Support Structure
  - Single/double steel cantilever
  - Mounting height
    - 7.5’ (bottom of model 6.5’)
  - Load cell
    - 1350 lb capacity (Fx, Fy, & Fz)
  - Vertical supports
    - 6” x 6” x ¼” steel tubes
  - Horizontal arm
    - 6” x 6” x ¼” steel tubes
  - Connector plates
    - 12” x 12” x ¼” steel



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Experimental Setup

- Validation
  - Model 1 (2’ x 2’ x 2.4”)
  - Results compared to:
    - AASHTO & ASCE 7-10 (Letchford 2001)
    - Previous research
- Blockage Effect Test
  - 2 flat panel models
    - 10’ x 2’ x ½” and 5’ x 1’ x ½”
  - 2 wind speeds
    - 45 mph and 90 mph
    - Results plotted for blockage correction

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Preliminary Phase I Results

- Tare Test
  - Longitudinal tare correction was determined to be a negative factor
    - Suction created behind model
    - Approximately 2% correction

Direction	Fx	Fy	Fz
0°	-0.73	0.04	-0.44
45°	-0.47	-4.45	4.96

- Free Stream Wind Correction
  - Mean correction 0.9984

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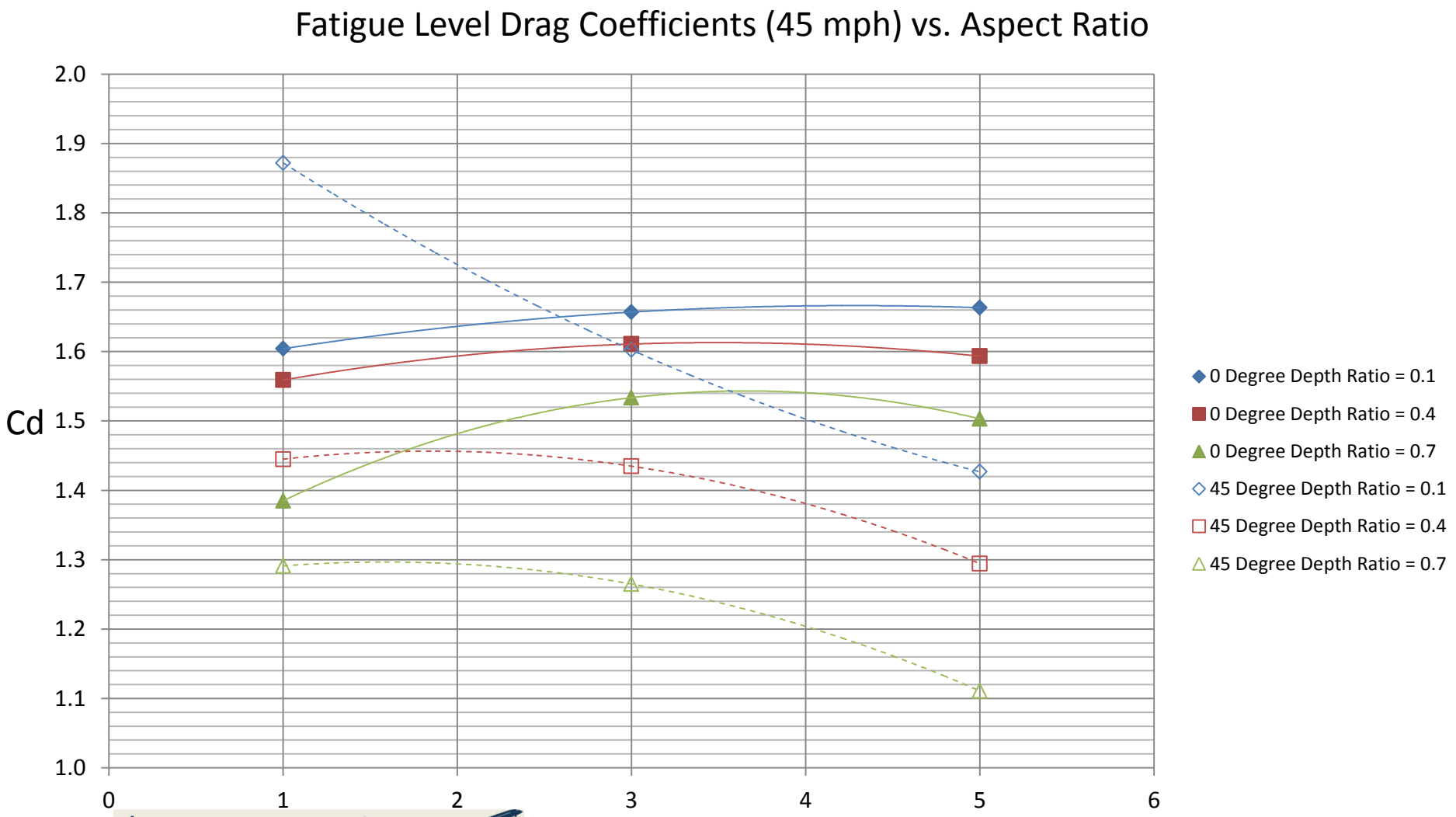
Preliminary Phase I Results

- Phase I – Drag Coefficient (Cd) Results

Model No.	Aspect Ratio	Depth Ratio	Cd	
			0°	45°
1	1	0.1	1.6042	1.8720
2	3	0.1	1.6570	1.6024
3	5	0.1	1.6633	1.4268
4	1	0.4	1.5590	1.4450
5	3	0.4	1.6109	1.4348
6	5	0.4	1.5934	1.2945
7	1	0.7	1.3850	1.2911
8	3	0.7	1.5336	1.2650
9	5	0.7	1.5031	1.1110

Preliminary Phase I Results



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Summary

- Phase 1 (fatigue level) testing is complete
- Results confirm the initial hypothesis that partial reattachment of flow over the prismatic VMS reduces the drag coefficient
- Results for the 45° approach are significantly smaller than the 0° approach
  - This will be investigated further in Phase 2 testing
- Phase 2 testing is scheduled to begin this Summer (2013)

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