Wind Loading on Historic Covered Bridges

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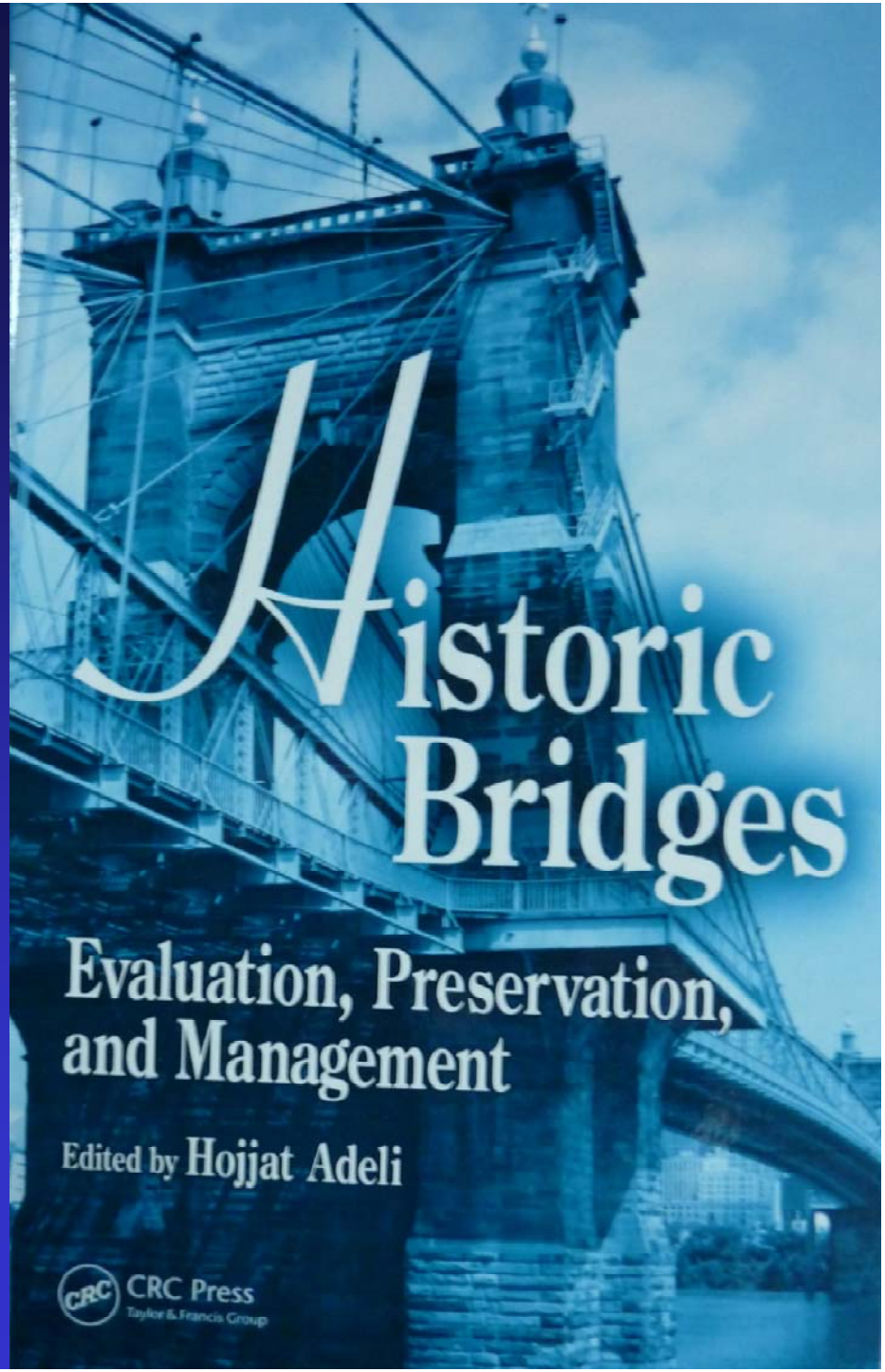
This Afternoon's Roadmap

- Introduction
- Existing Wind Provisions for Covered Bridges
- Wind Tunnel Tests
- Data Analysis
  - "Cladding" (Roofing and Siding) Loads
  - Forces in Main Members
- Conclusions

This project initiated in Ohio…

8th Historic Bridge Conference, Columbus, April 2008



A gap between bridges and buildings…

- AASHTO *Guide Specifications for Design of Pedestrian Bridges* (1997) specifies 3.6 kPa (75 psf)
  - **Seems excessive!** May require strengthening end portals with structural steel
- ASCE *Minimum Design Loads for Buildings and Other Structures* less stringent

Some confusion in practice

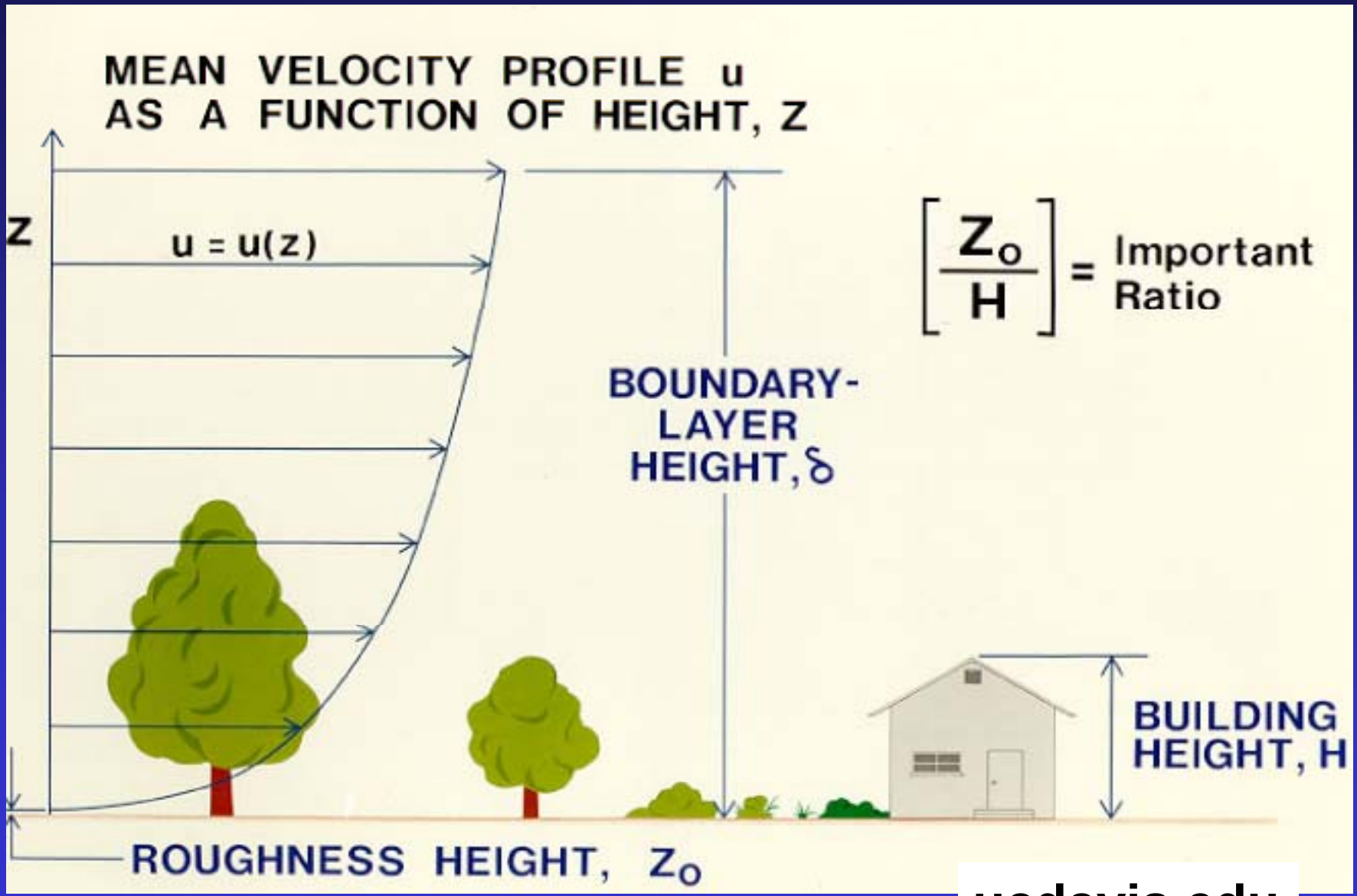
Bridge	Source	Design Load
Burkeville	Lee & Brenner (2008)	0.58 kPa (12 psf)
Hutchins	Bicja (2008)	Walls: +/-1.41 kPa (29 psf) Roof: +0.33/-0.88 kPa (+7/-18 psf)
	AASHTO (1997)	3.6 kPa (75 psf)

Research Objective:

What load should be used?

Western's Boundary Layer Wind Tunnel Laboratory

“Boundary Layer”



ucdavis.edu

Maumee River Bridge in tunnel

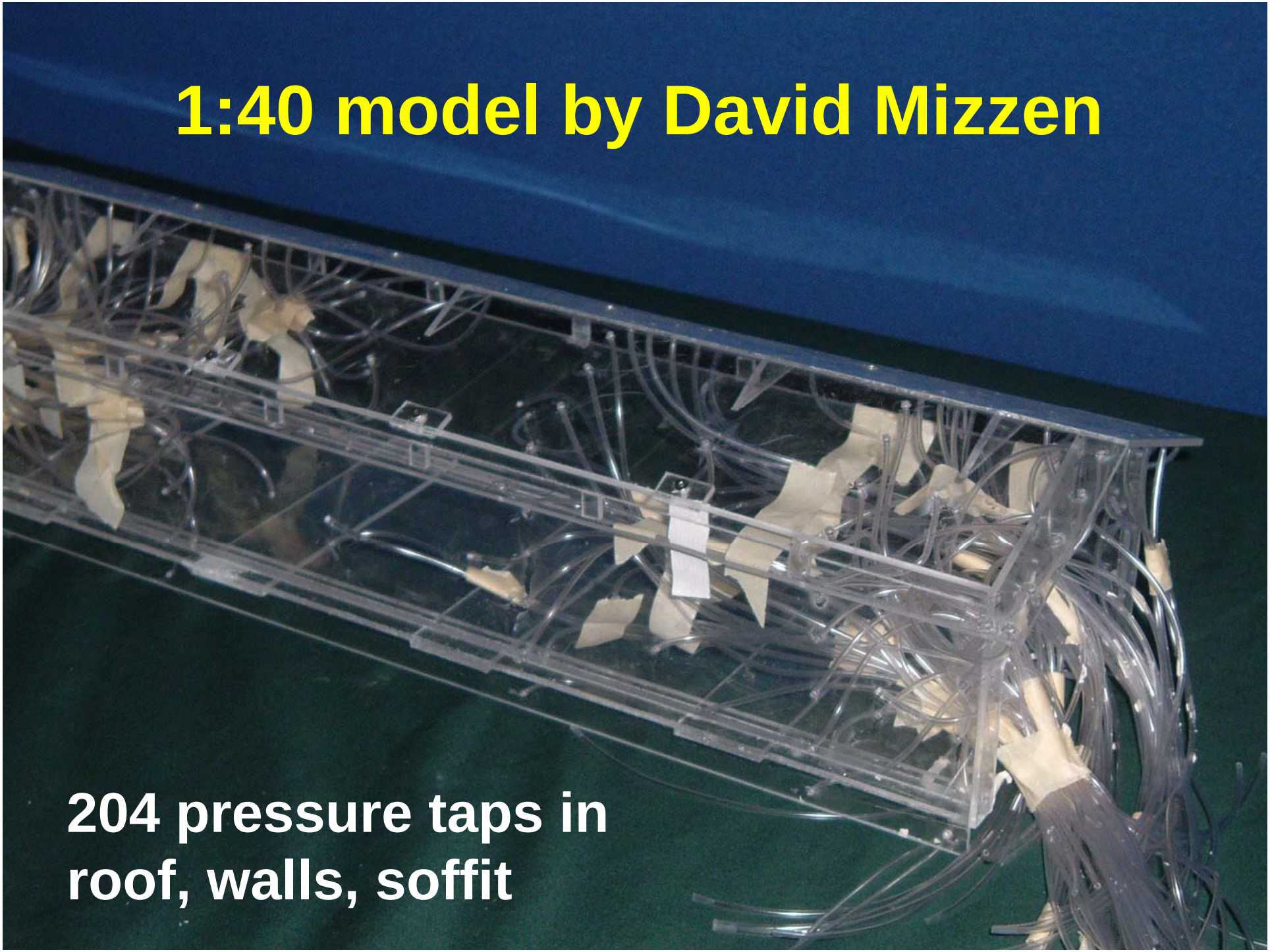
Getting by with a little help from our friends…

- Hoyle, Tanner & Associates Inc. graciously provided:
  - Drawings of a representative historic covered bridge
  - STAAD computer model
  - Thoughtful feedback and advice throughout the project!

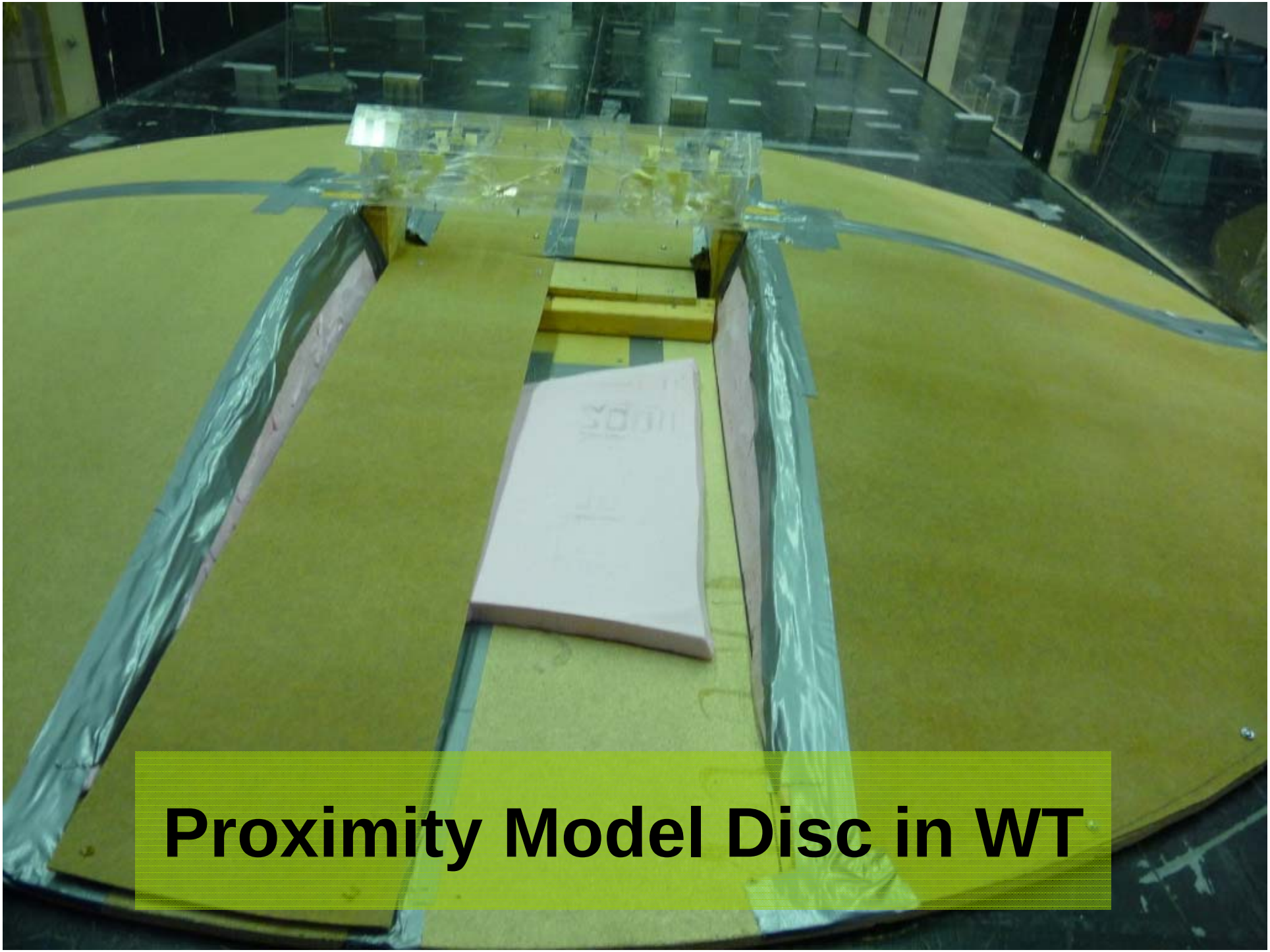
Hoyle, Tanner & Assoc., Inc.

Hutchins Covered Bridge – before rehabilitation

1:40 model by David Mizzen



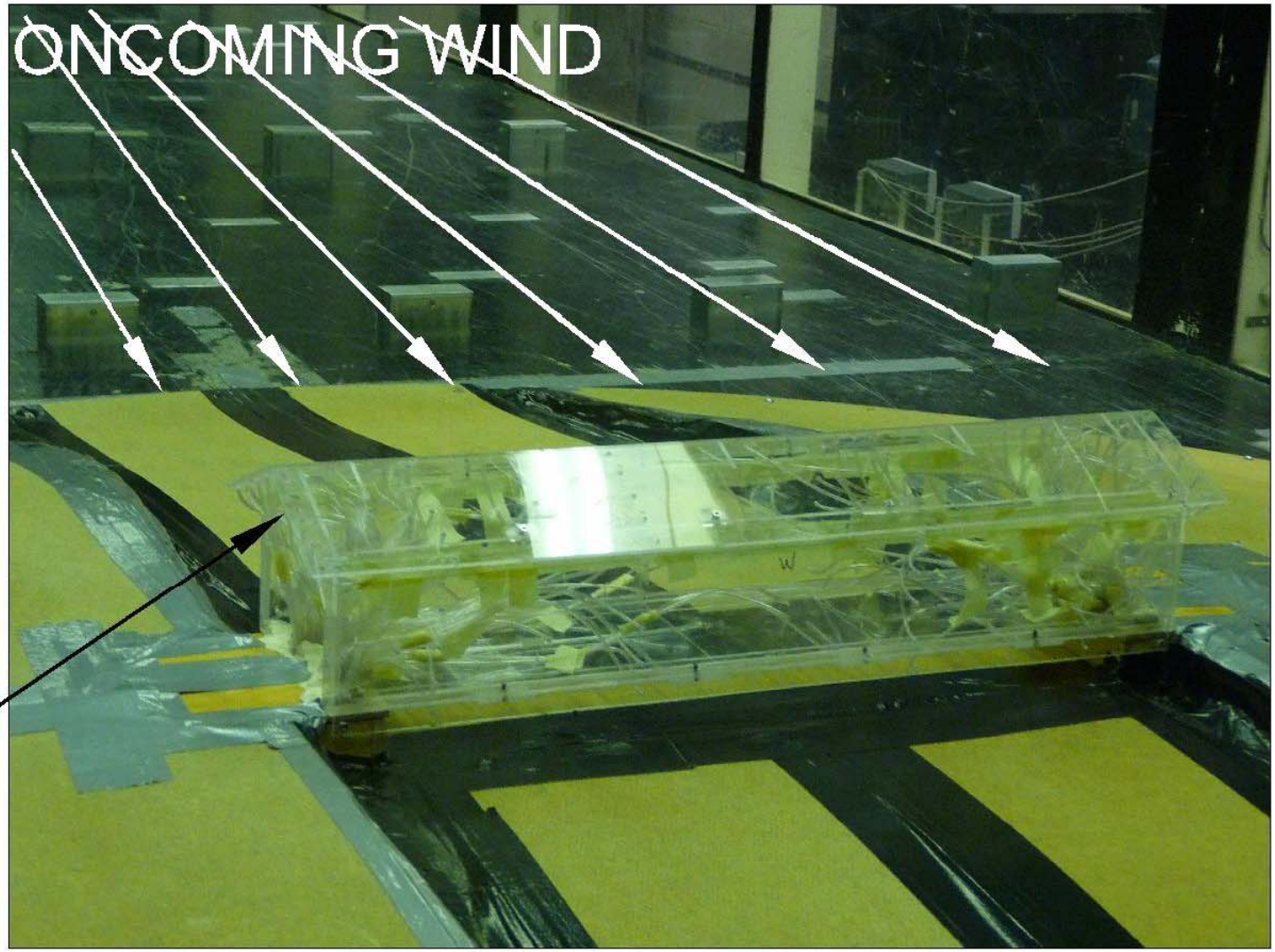
204 pressure taps in roof, walls, soffit



Proximity Model Disc in WT

Test Program

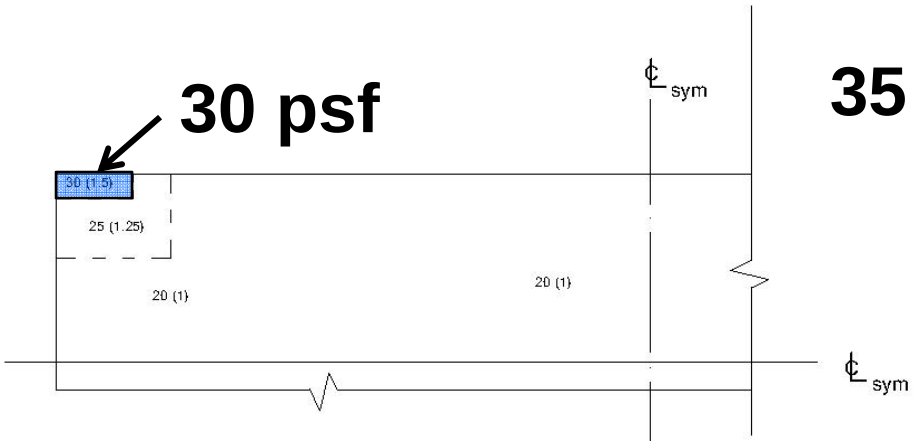
- **10 wind angles**
- **3 water clearances**
- **3 side opening ratios**



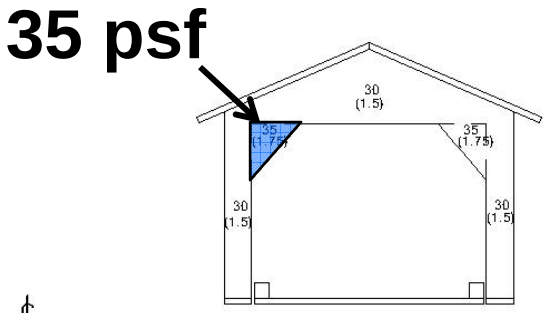
Data Analysis

- Cladding pressures
- Main member force effects
- Worst cases for walls with:
  - small openings
  - any water clearance
  - wind from any direction

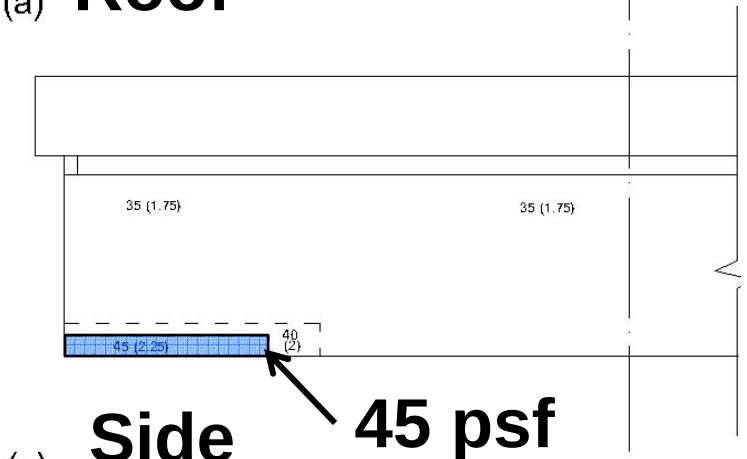
Peak Positive Net Cladding Pressures



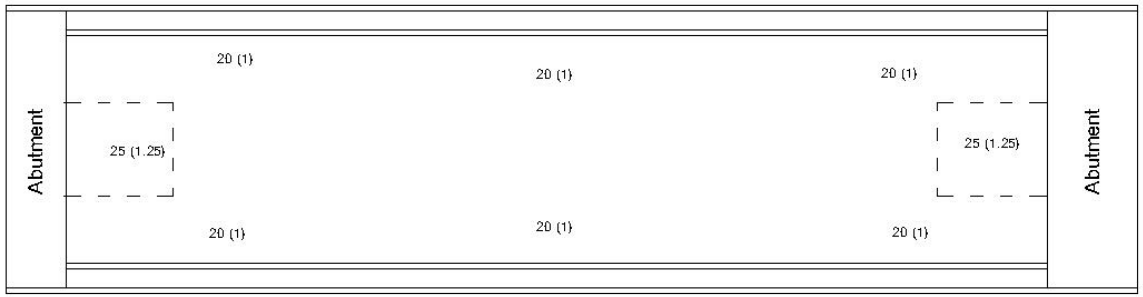
(a) Roof



(b) End

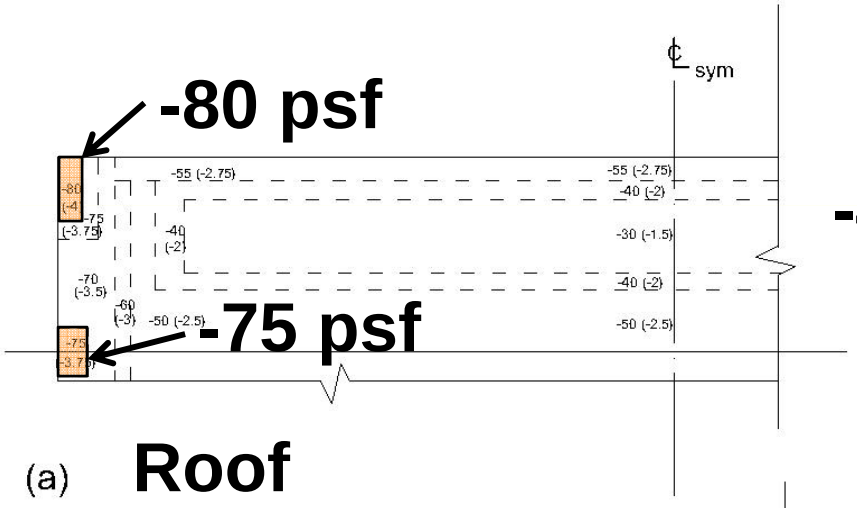


(c) Side

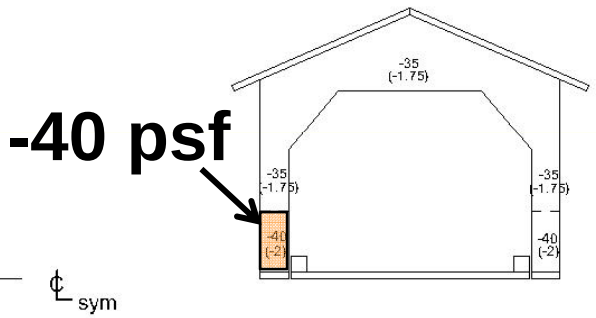


(d) Soffit

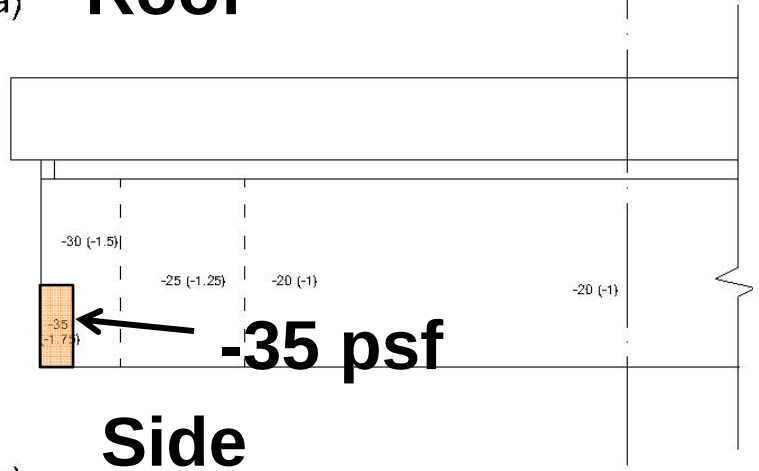
Peak Negative Net Cladding Pressures



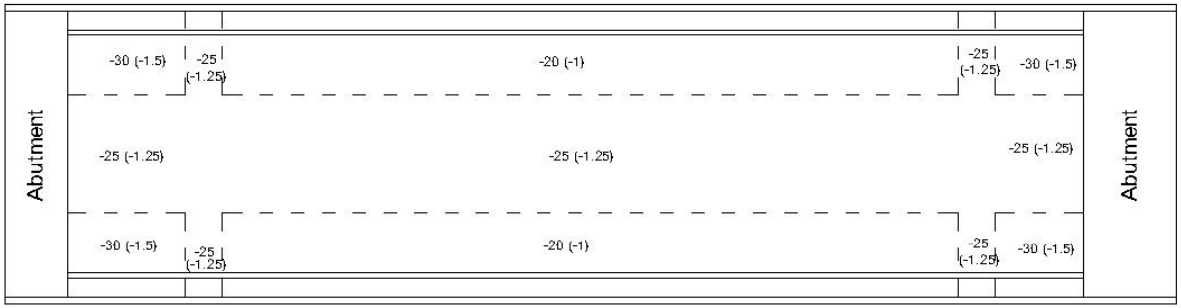
(a) Roof



(b) End



(c) Side



(d) Soffit

Hurricane Hugo, North Carolina, 1989

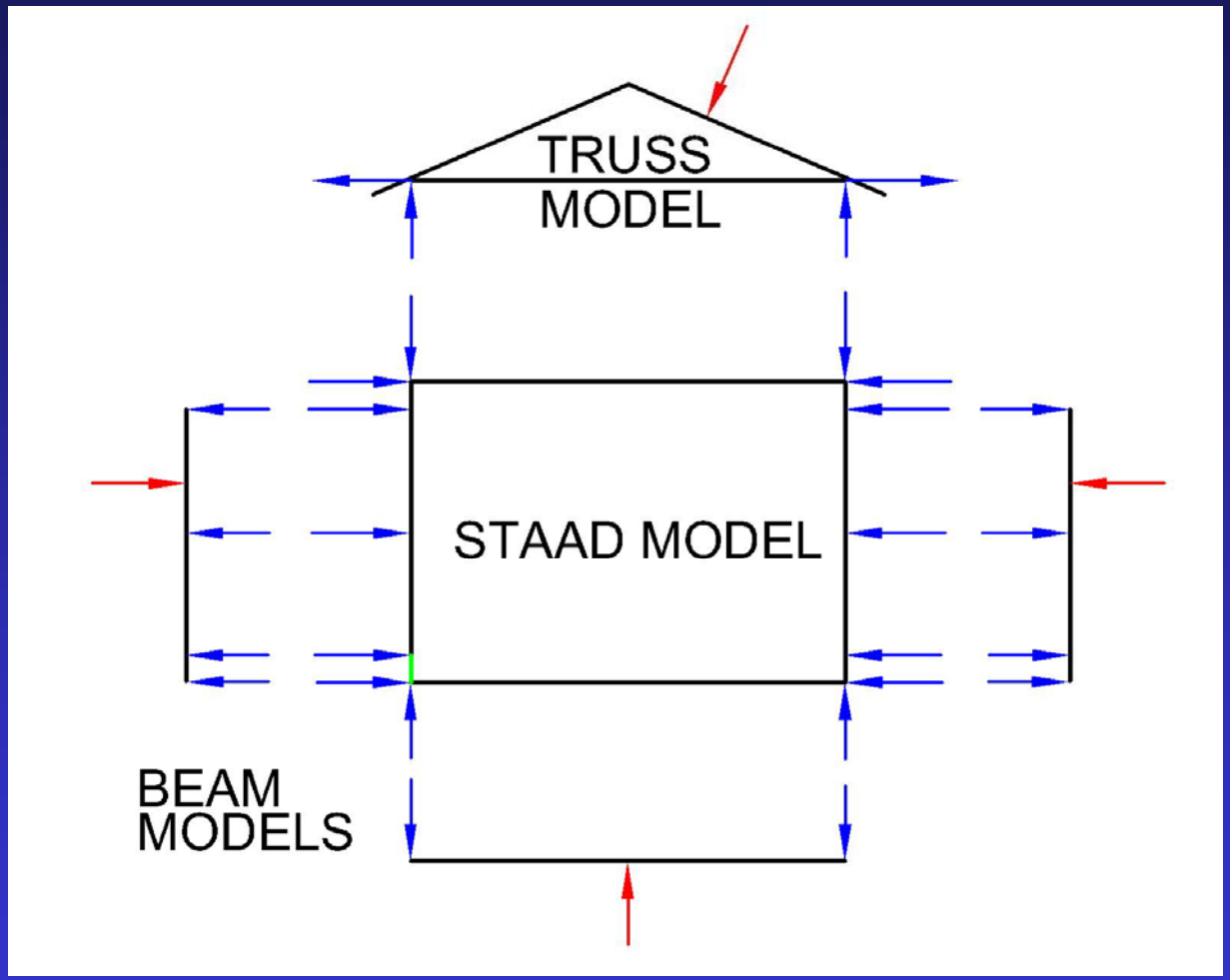
Gable Roof Damaged ← | → **Hip Roof Undamaged**

Member Forces Analysis

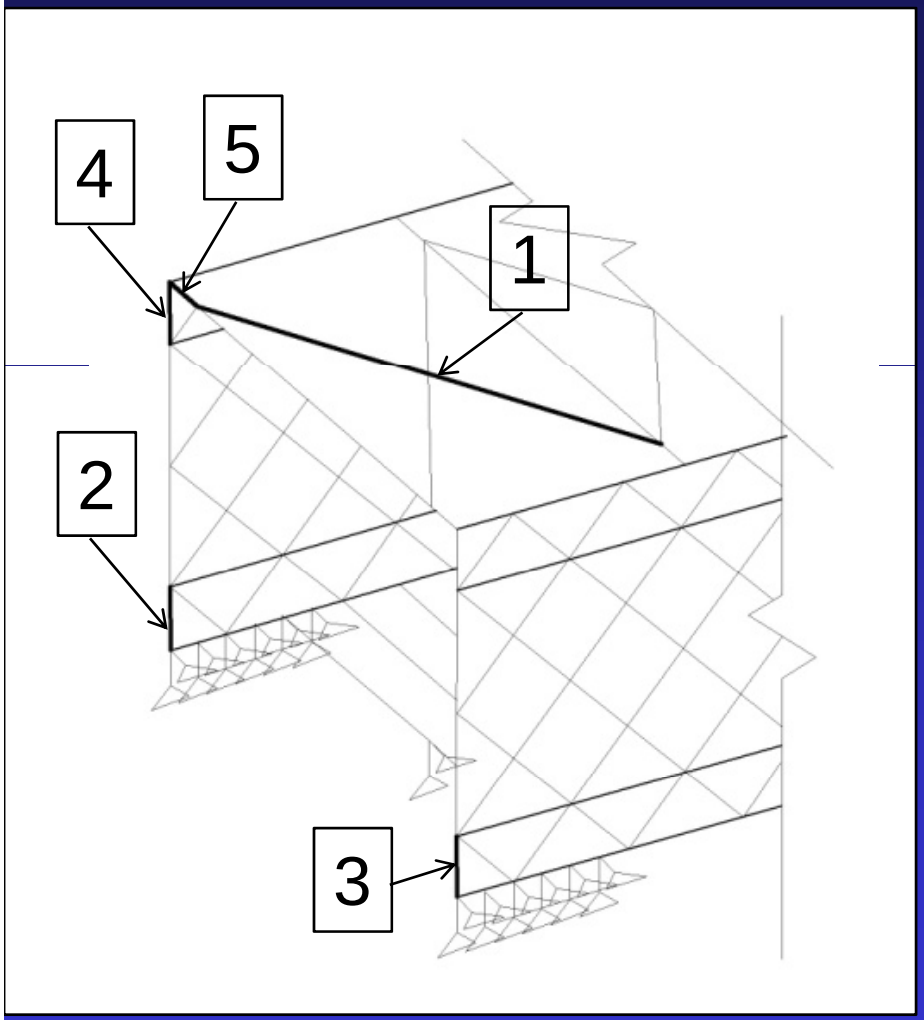
Time history of pressures

↓

Time history of member forces



Comparison of Member Forces



Member (Force type)	WT AASHTO	WT ASCE 7
1 (F)	0.56	0.76
2 (M)	0.65	0.84
3 (M)	0.61	0.83
4 (F)	0.67	1.03
4 (M)	0.62	0.70
5 (F)	0.64	0.90
5 (M)	0.66	0.94
Avg.	**0.63**	**0.86**

ASCE 7 stringent

AASHTO very stringent

Conclusions

1. Check main wind-load resisting members using wind loads from ASCE 7 as those specified in AASHTO (1997) are excessive.
2. The 3.6 kPa (75 psf) pressure specified by AASHTO is accurate for cladding suctions at the ridge and eave at the end of the roof but is excessive elsewhere.

Paper Available

Mizzen, D., King, J.P.C., and Bartlett, F.M. (2010): "Wind Loading on Historic Covered Bridges". *Proceedings of the 8th International Conference on Short and Medium Span Bridges*, Niagara Falls, Canada.

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- **B. Schmidt**, Dillon Consulting Ltd., London, Canada
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Questions?

West Montrose Covered Bridge, Waterloo Region, Ontario (T. Scott photos)

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