F5. Elie, Manitoba. June, 2007.

The 'Three Little Pigs' Project

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Western

"We know enough about the wind loads on low buildings now, so that disastrous failures (such as seen during Hurricane Andrew) to storms other than severe tornadoes, are much more likely to be due to faults in codes, or construction and inspection practices, than due to lack of basic wind engineering knowledge."

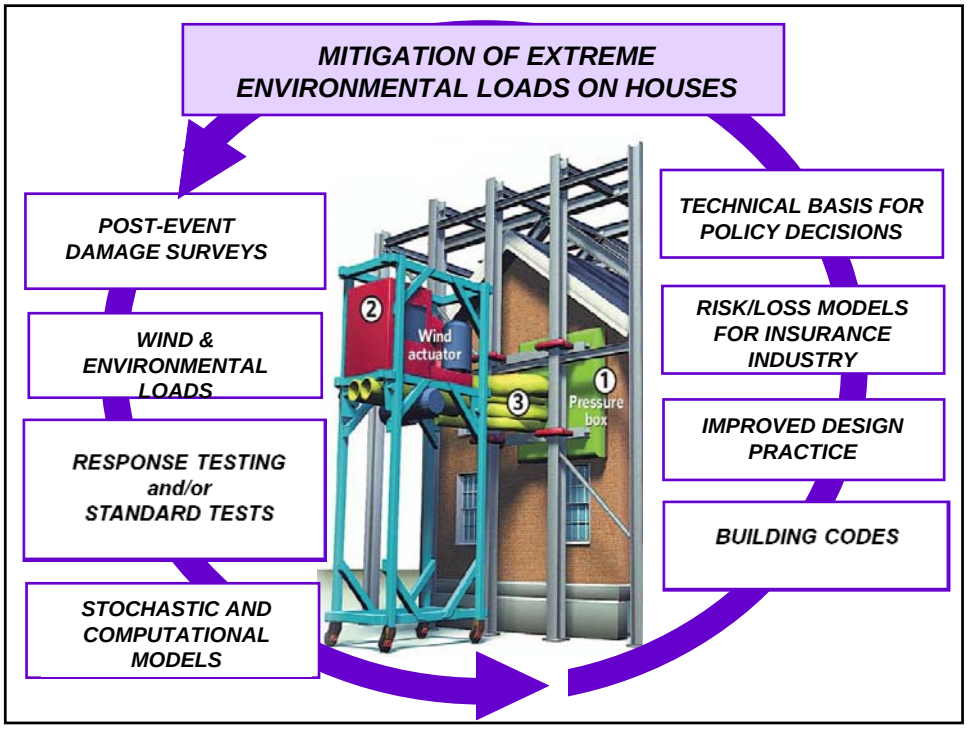
D. Surry, 1999

Vision Statement

To find optimal solutions which mitigate damage to homes, and other light frame structures, under extreme environmental conditions; conditions such as wind, wind-driven rain, snow, and the various factors that support mould growth.

Detailed Project Objectives

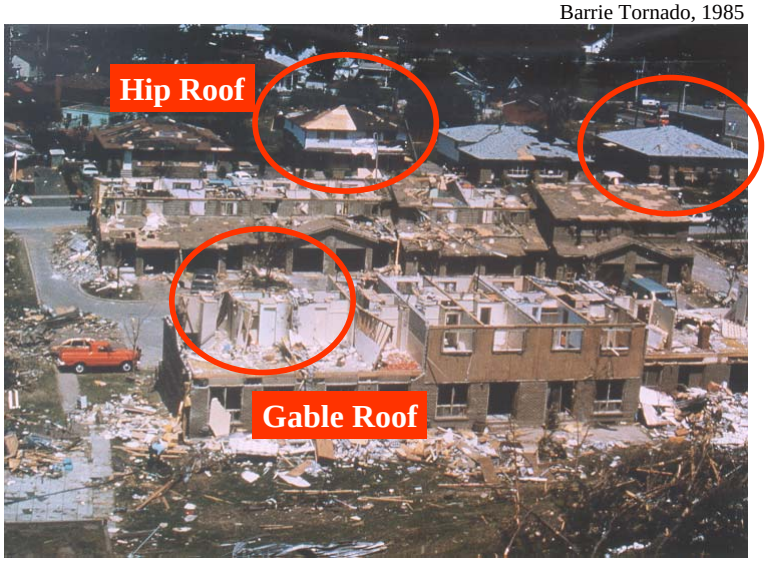
1. Develop new testing methods which allow the examination of structural and component responses under realistic loads.
2. Calibrate simplified industry standard tests against the “reality” of dynamic wind loads and current/future building codes.
3. Understand the environmental conditions under which mould grows.
4. Find prescriptive design solutions for wood-frame structures (houses) and building components, incorporating effects of errors/variability, for wind and other environmental loads.
5. Improve the design and installation of building materials, considering the future climate, in partnership with builders and manufacturers.
6. Improve computational and simplified experimental methodologies so other cases can be examined.
7. Educate the public on safety issues in partnership with governmental agencies and insurance industry.
8. Perhaps… develop/test new building systems for houses which perform the key aspects of housing systems (environmental control and structural reliability) in a more unified manner

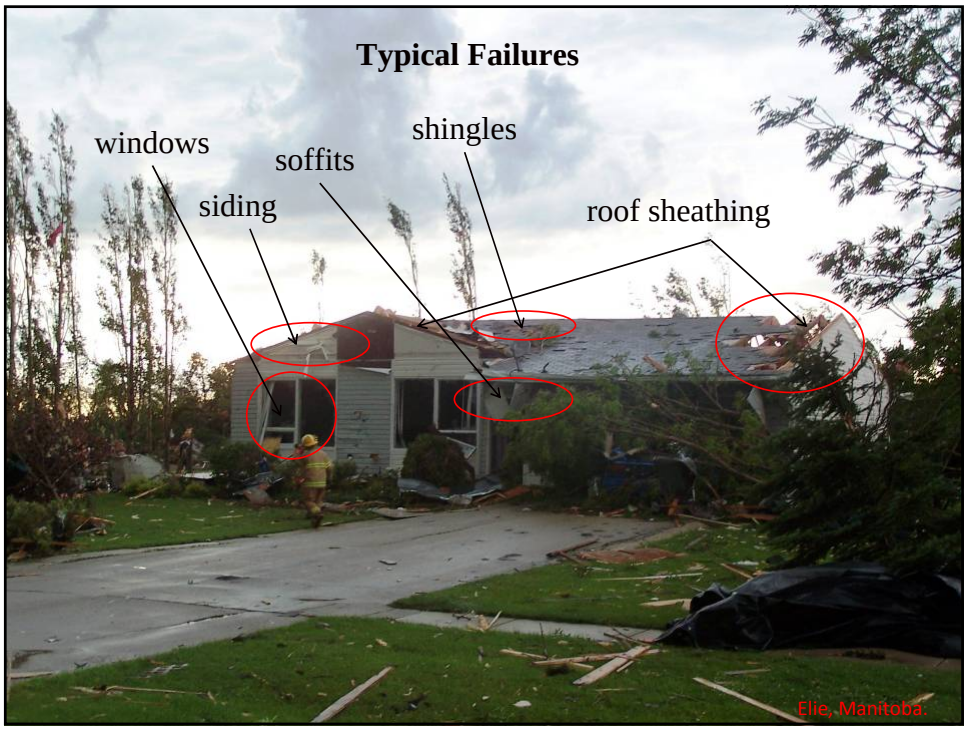


Damage surveys illustrate common problems.

Here, the differences in effects of roof shape are clearly illustrated.

Barrie Tornado, 1985



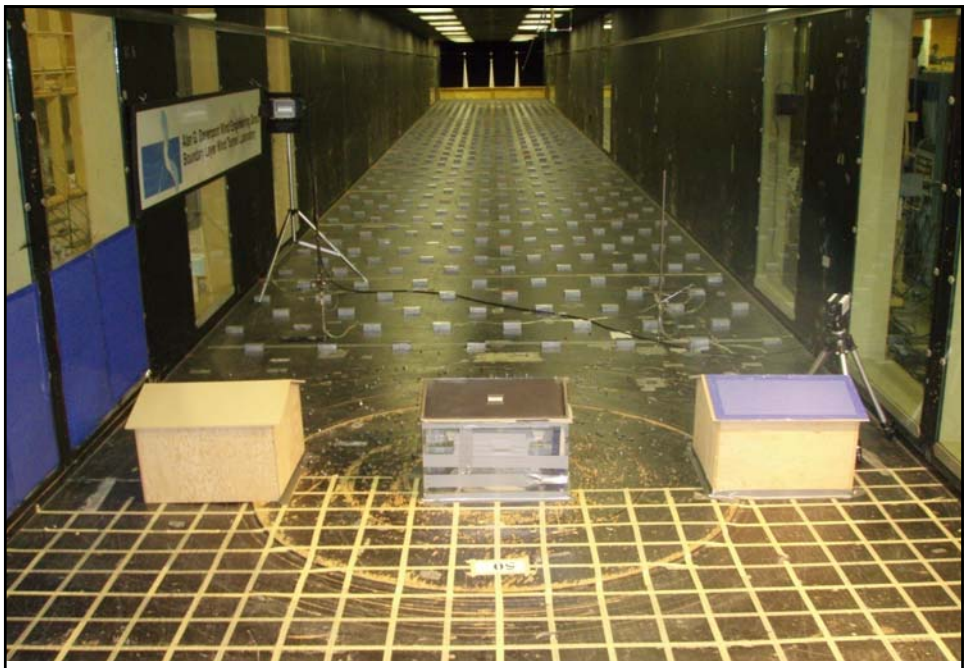



car
‘missing’ house


same car
MISSING hold-downs

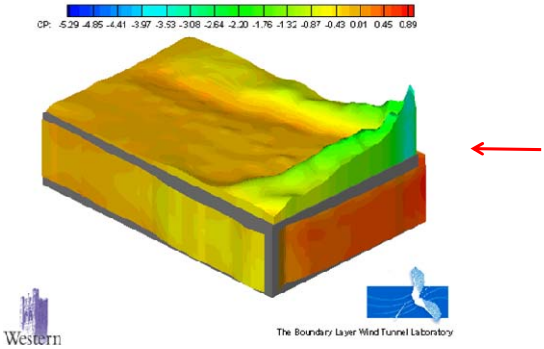
Missing foundation connections are a life safety issue in tornadoes

Details such as this are important to observe and identify in damage surveys so that accurate engineering analyses can be performed.



Wind tunnel testing is used to determine wind loads

Wind Loads on a Low-Rise Buildings



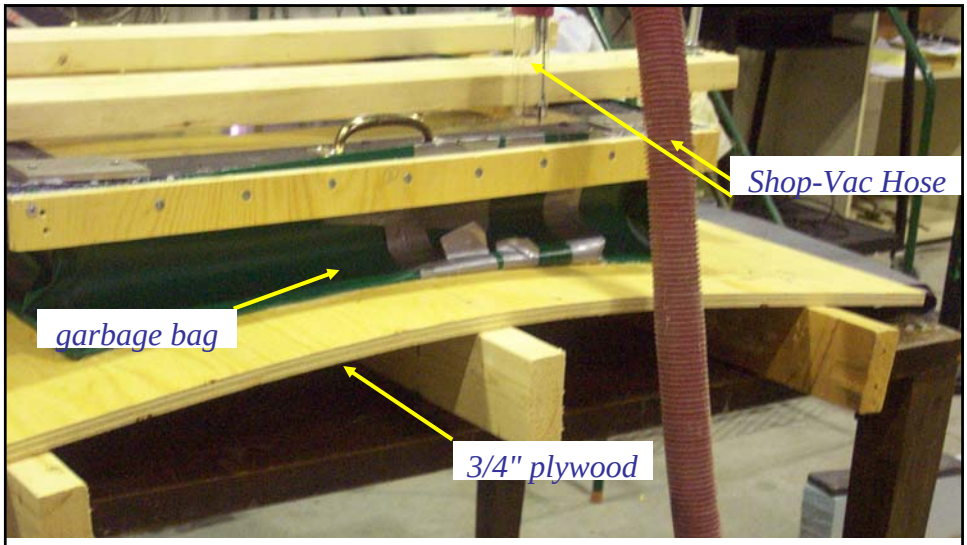
Wind induces pressures on the surfaces of buildings in the same way that lift is generated on an aircraft.
The pressures vary significantly with location on the building, and in time, because of turbulence.

At the Three Little Pigs Project, we apply the wind loads to full structures in a novel way:

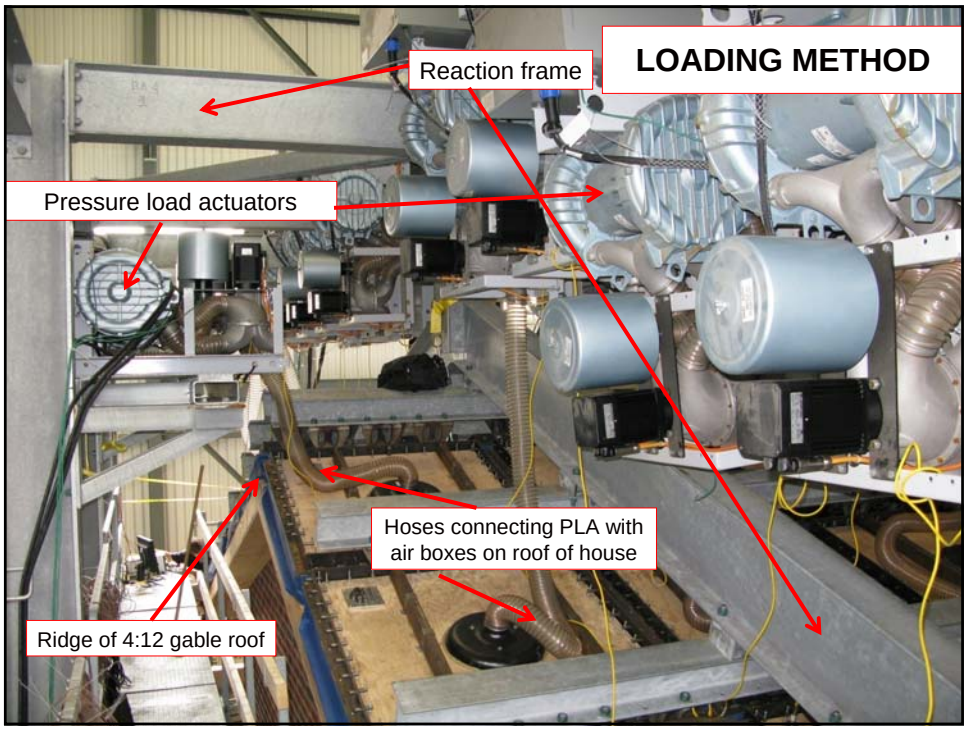
by applying the pressures directly, rather than using an absolutely enormous wind tunnel

This has many advantages:

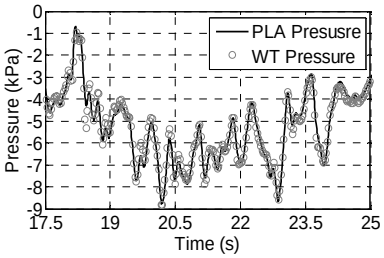
- Much less expensive
- Wind loads can be directly linked to building codes and other analyses

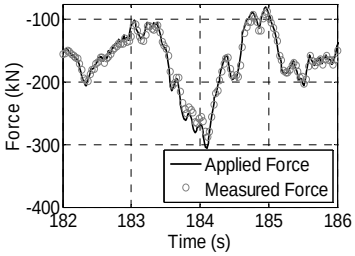


The loading concept is simple;
we replicate the pressures that the wind induces.
Fans are used, NOT TO BLOW WIND, but more like a vacuum cleaner!



Technical performance is outstanding!

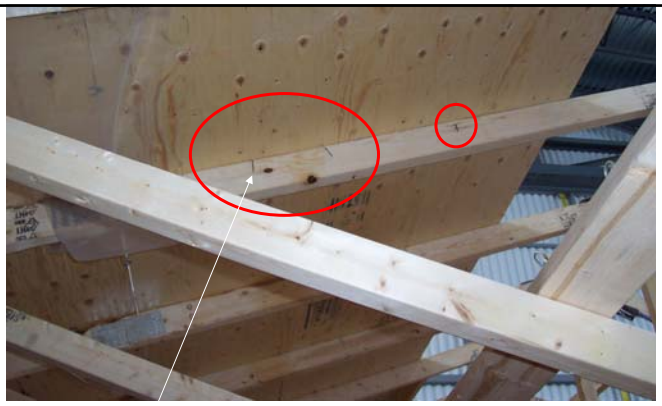


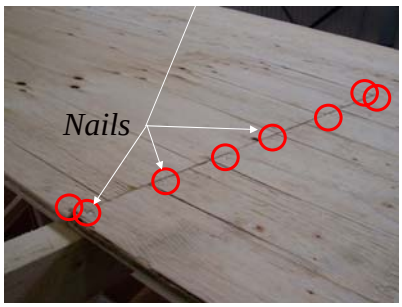


Wind tunnel pressure time histories are used as the basis for the full-scale experiments.

Note that the load changed by a factor of 3 in about ½ second (in the graph on the right)

Full-scale tests on a fully-instrumented 2-storey house



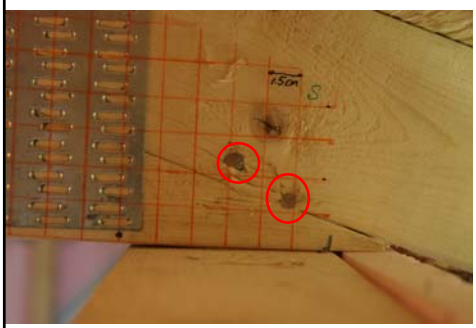


Variability in performance arises because of errors and variability in materials.

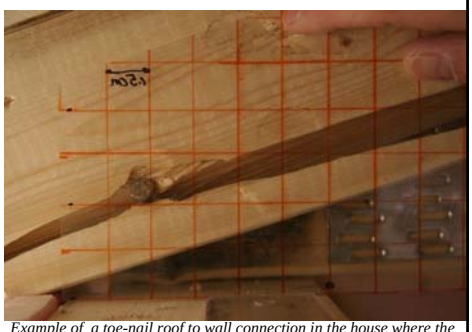
(Photos of 3LP test house)

Roof-to-Wall Connections

- **<u>Every connection in the house has been recorded</u> to aid in the interpretation of the experimental data and to aid computational modeling.**
- **Toe-nail connections are highly variable**
- **These data will be used for the development of probabilistic failure (risk) models, and to aid in the interpretation of the experiments**

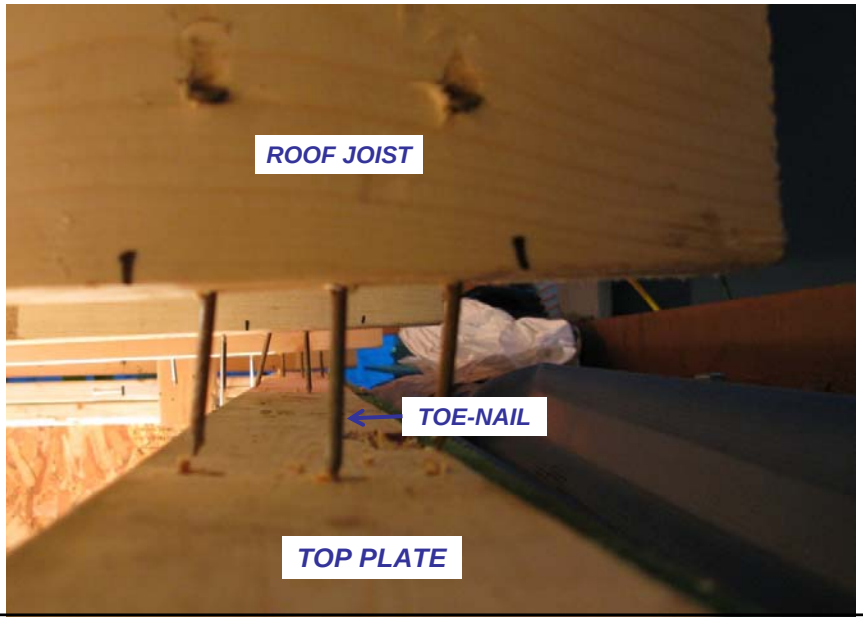


A typical toe-nail roof to wall connection in the test house



Example of a toe-nail roof to wall connection in the house where the nail has split the wood and offers very little hold down force.

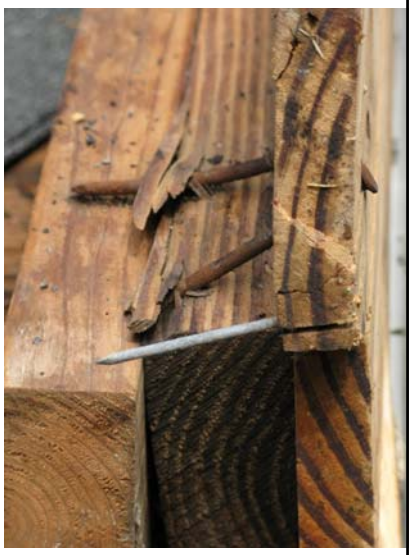
Toe-nail failure in test house



… inexpensive, but is this really an effective mitigation measure?

southern Spain

Water Damage – Hurricane Gustav



This house lost it's roof because of missing toe-nails

… but rocks would have only made things worse for the neighbours.!

Water Damage – Hurricane Gustav

2nd floor water damage, beneath missing roof

←

1st floor water damage

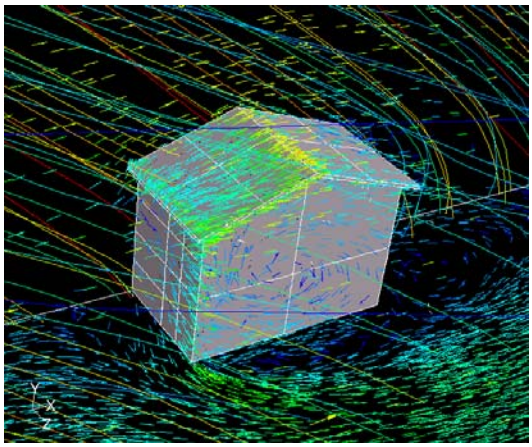
→

Water goes everywhere!

Mould Damage following storms

UWO has developed the first ever real-time mould sensor so that conditions for formation can be accurately documented

Wind-Driven Rain



Details also matter for mitigation of wind-driven rain problems

This issue is potentially going to worsen in the future climate

Summary

UWO has a new full-scale testing facility to study and mitigate the effects of extreme environmental loads in a realistic, cost-effective and efficient way.

Our overall program involves all significant effects of environmental loads on low-rise structures, and we have all of the tools in place to study these effects.

We are continuing to build the partnerships required to implement the results coming out of our Lab.

This will lead to optimal design for cost effective and realistic mitigation strategies, improved building codes for the climate of the future, and the technical basis for policy decisions.

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