

# Failure modes for small-scale buildings in wind-storms

Is it better if the cladding fails first?

# Wind load on buildings

Wind load on a building with roof & walls is very high

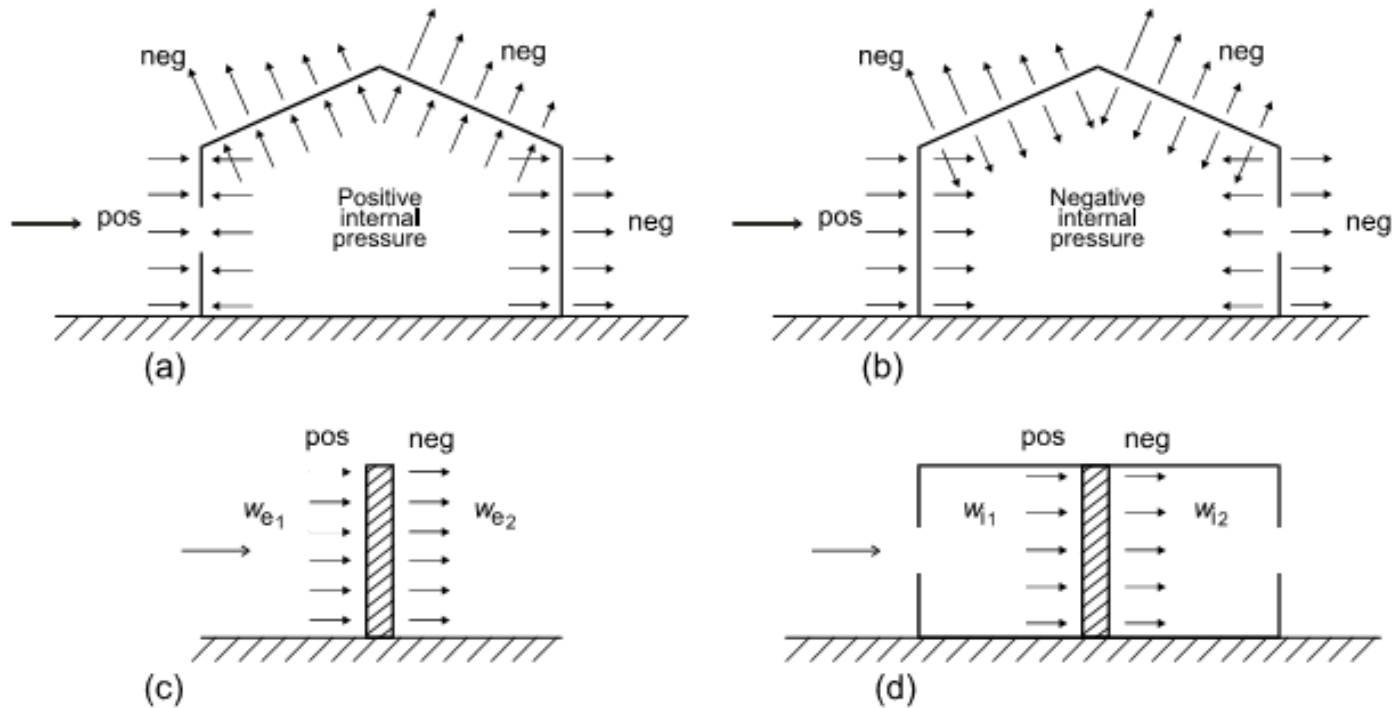
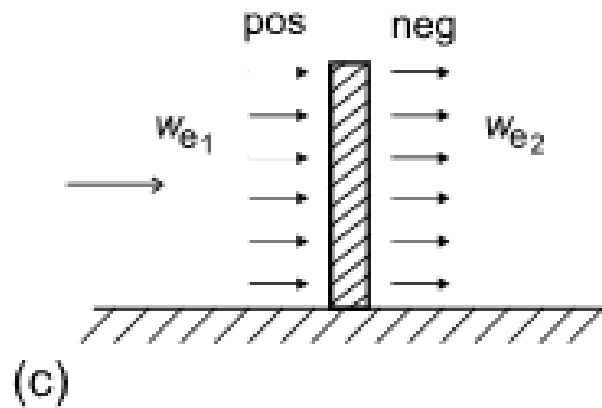


Figure 5.1 — Pressure on surfaces

<b>Enclosure Classification</b>	<b><math>(GC_{pi})</math></b>
<b>Open Buildings</b>	0.00
<b>Partially Enclosed Buildings</b>	+0.55 -0.55
<b>Enclosed Buildings</b>	+0.18 -0.18

# Wind load on walls

- If the roof fails – just lateral forces and no uplift. Will still destroy a poorly built frame.



# Wind load on open buildings

If the walls fail we're left just with pressure forces on the roof. Some lateral, some uplift, but a major reduction in force if unobstructed:

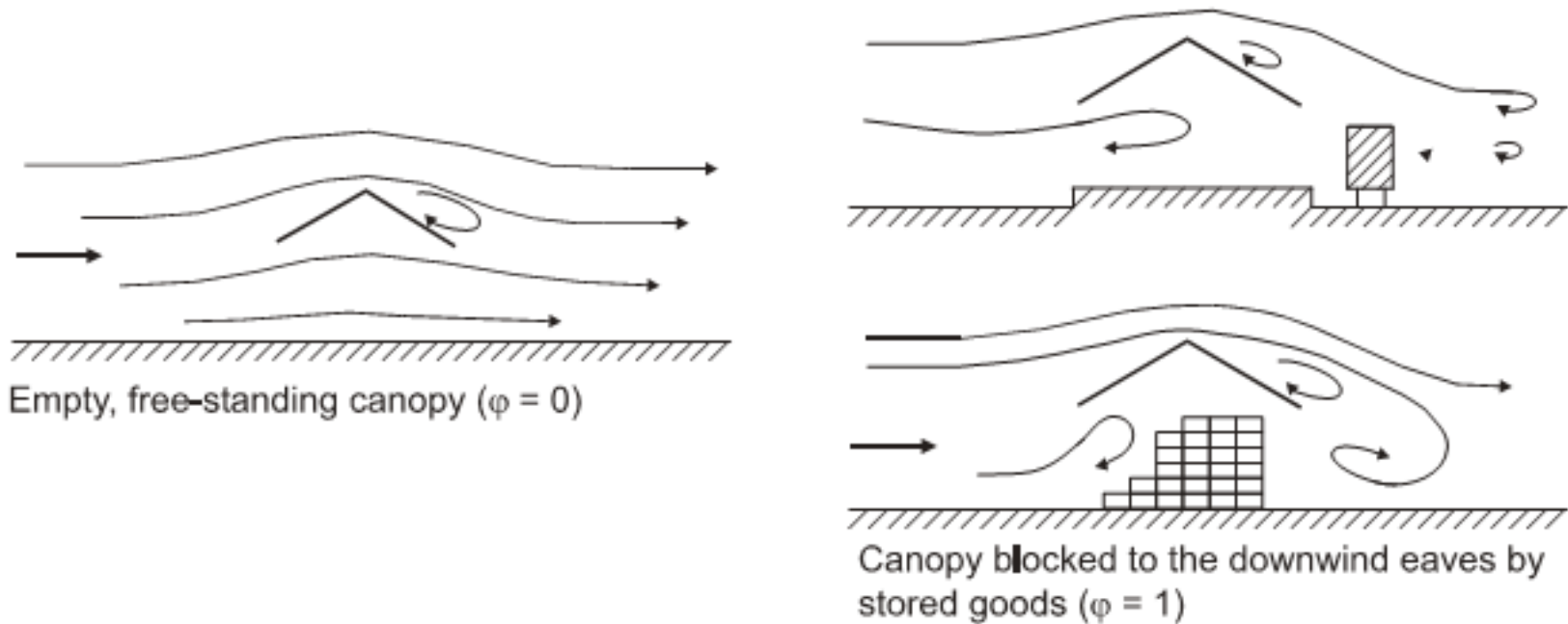


Figure 7.15 — Airflow over canopy roofs

# Limit state design

In structural design, there are a number of limit states to guide the design, including:

- Ultimate limit state (ULS): Does not collapse or suffer any structural failure
- Serviceability limit state (SLS): Remains fit for purpose
- Accidental limit state: Suffers some structural failure, but protects life

For an action on a building, such as storm, a decision is to be made whether the building must simply survive without collapse, must suffer no structural failure, or must remain fit for purpose.

# What does a building need to do in storm?

- Protect its occupants
  - Critically important
- Protect people's belongings
  - Important for psychological well-being, livelihoods and financial security
- Survive to offer on-going protection
  - Also important for psychological well-being, livelihoods and financial security

# What's the job of a building in a storm?



Building function	With loss of roof or walls	Without loss of roof & walls
Protect occupants	Possibly	Yes
Protect belongings	No	Yes
Survive undamaged	No	Possibly
Survive but be repairable	Possibly higher likelihood	Possibly
Flying debris	Likely	Possibly



## Recommended guidance

- Sacrificial cladding is not generally suitable for permanent, non-engineered buildings subject to wind storms.
- For temporary and/or transitional buildings, sacrificial cladding may be appropriate.
- If sacrificial cladding is used:
  - There must be a reliable plan for life safety, e.g. evacuation or safe rooms
  - The loss of possessions has to be deemed acceptable
  - The occupants must know and understand that the cladding is sacrificial
- Proper consideration must be given to the effect of wind-borne debris, and the durability of cladding.

# Wind-borne debris



# Wind-borne debris



# Wind-borne debris



- May cause injuries
  - Little hard evidence, but 23% of the fatalities (Japan, 63 total) of Typhoon Mireille in 1991 were due to wind-borne debris.
- May damage adjacent buildings and cause further failures.
  - In urban areas wind-borne debris will hit other buildings
  - In hurricane Andrew, wind-borne debris was the largest single cause of damage to other buildings





(a) September 17th, 2006, Nobeoka-city



(b) September 5, 2005, Miyazaki-city  
(courtesy of Miyazaki Meteorological Station)

Figure 12: Damage Marks by Wind-borne Debris due to Tornadoes (Tamura, 2007)

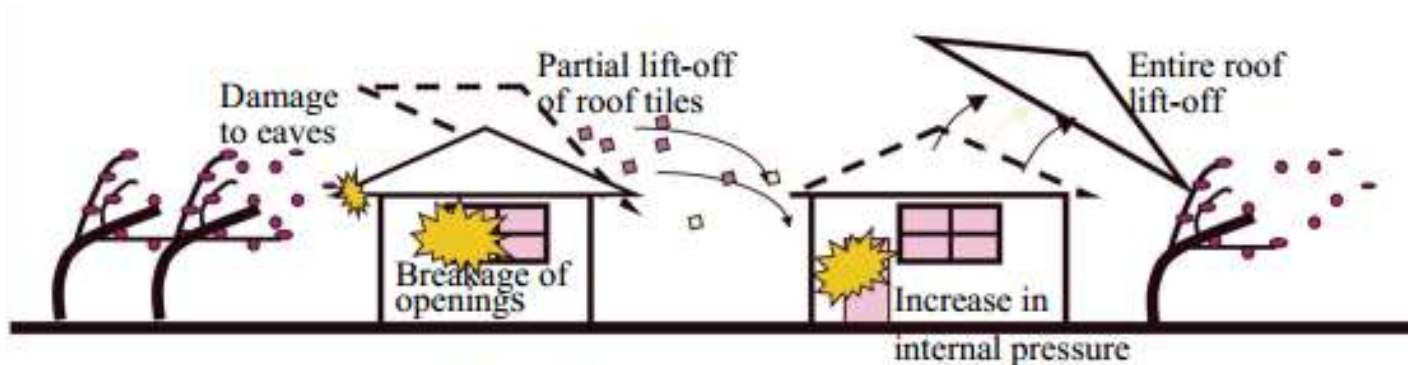
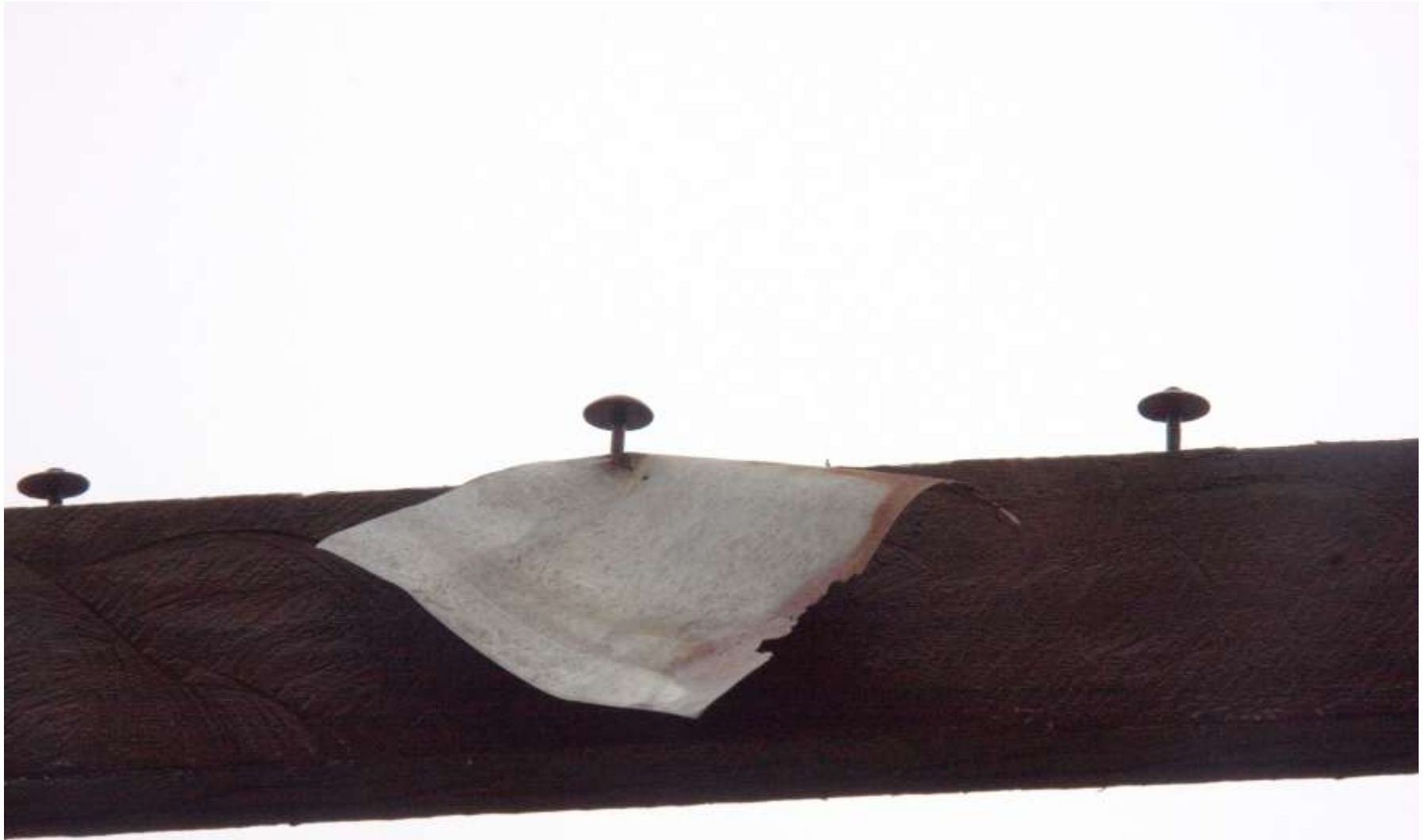


Figure 15: Damage Chain

# Durability



# Durability



There is an economic cost to having thin or poor quality sheeting, as it needs to be replaced more often.

Poor quality fixings are similarly not durable, and mean well-fixed cladding becomes poorly fixed within a few years.

## Suggestion....

I would like to produce a short guide (for the shelter cluster?) to making choices about sacrificial cladding, cladding quality & durability which makes people think about:

- Limit state design
- Wind-borne debris
- Durability & economics

Would there be appetite for collaborating on this?



# Suggested reading



## WIND-INDUCED DAMAGE TO BUILDINGS AND DISASTER RISK REDUCTION

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