Building Science Summit New Zealand

Stijn Van den Eeden

Do Warm Roofs Last?

- History
- General principles
- Typologies
- Vapour barrier
- Pathology
- Safety nets

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Stijn Van den Eeden

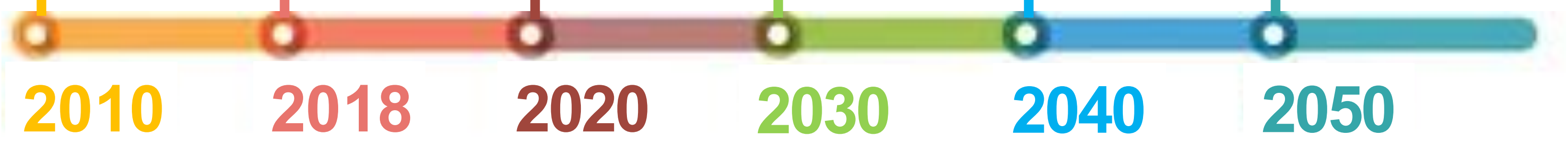
History

- 1930's: pioneers
- 1960: early adoption
- 1980: response to 1973 oil crisis

History

TIMELINE in EUROPE Directive (EU) 2024/1275

- 2007: regional EPBD
- 2010 EPBD (European Performance in Buildings Directive)
- 2018 New Public Buildings are Nearly zero energy
- 2020 All new housing Nearly zero energy
- 2030 ZEB target and public by 2028
- 2040 Deep decarbonization phase
- 2050 Net-zero CO2 Paris Agreement



History

Babbage
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NEW ZEALAND

- 2020 Building for Climate Change Frameworks Consultation
- Emissions reduction plan incl voluntary energy performance ratings for non-residential buildings

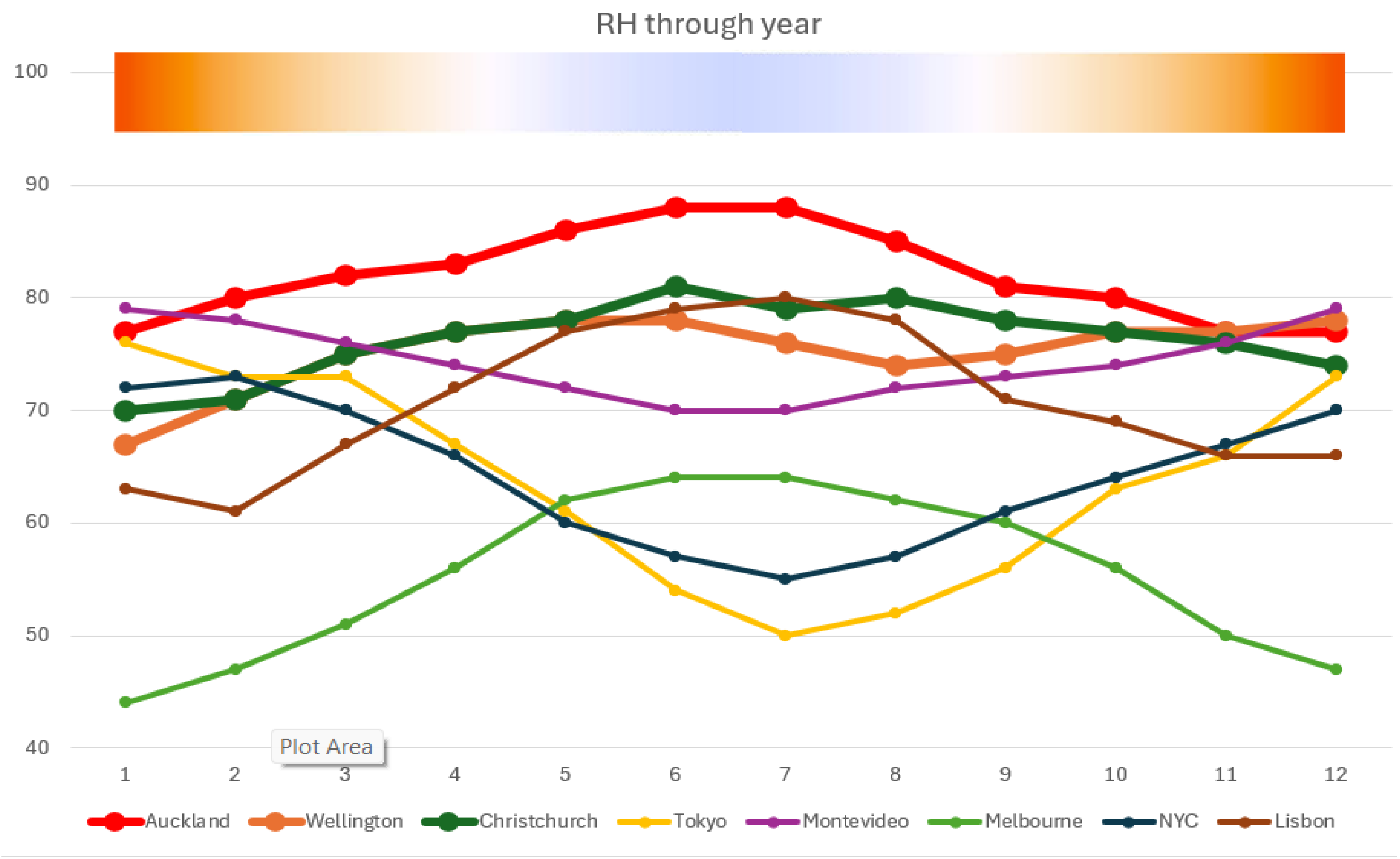
NZGBC requested

- Require Energy Labeling on existing buildings sold/leased by 2024

Changes to section H1 of the Building Code

Building element	Construction R-values (m²·K/W)[1]					
	Climate zone 1	Climate zone 2	Climate zone 3	Climate zone 4	Climate zone 5	Climate zone 6
Roof[2]	R6.6	R6.6	R6.6	R6.6	R6.6	R6.6

Our climate – oceanic temperate



General principles

Study the interactions between ***heat***, ***moisture*** and ***air*** as they move between indoor and outdoor environments through the fabric of the building.

Wind versus **air** versus **vapour** barrier. Damp closed = also airtight but not the other way around. S_d = equivalent air thickness (m) and μ_d vapour resistance diffusion factor (-)

Cold air cannot absorb as much moisture as warm air

Condensation

- **Surface** condensation (lack of insulation)

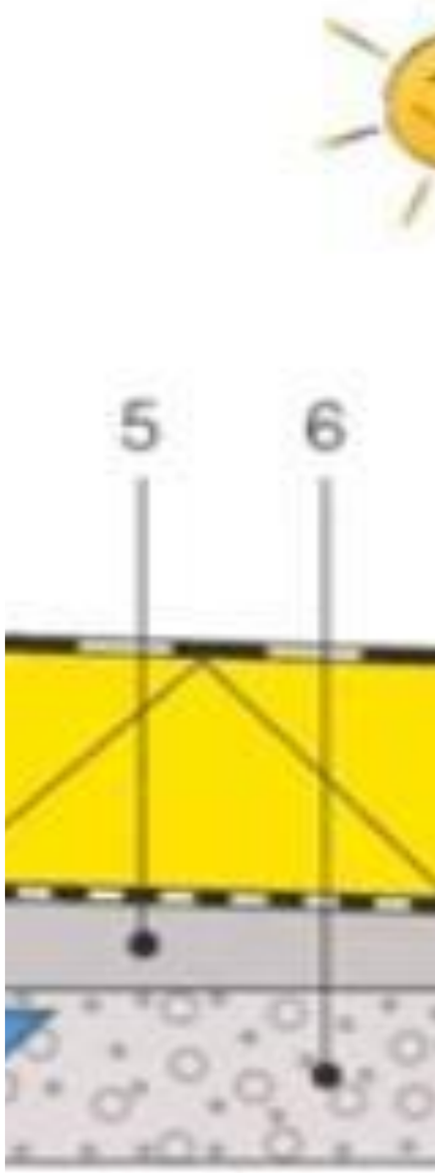
- **Undercooling** or condensation due to **night-sky radiation** (outside layer through night radiation) can also happen inside roof construction

Interstitial

- **Interstitial** condensation (warm humid air passed insulation, cools and condensates). By convection (airtight) or diffusion (vapour resistance – less and slower).

Inverted

Inverted condensation in the summertime – 3 conditions



Roof typologies

Pitched roof

- Open jointed
- Rain proof, but air and damp open, condensation in roof allowed.
- Slope of min 3° or more
- Focus: rainproof, air tightness warm side insulation in combination with damp-open underroof

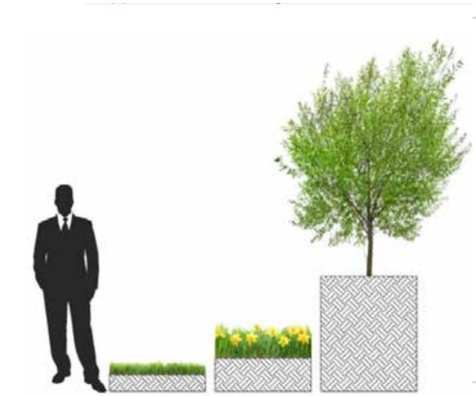
Roof typologies

Flat roofs

- Watertight joints
- Water resistant, airtight and damp proof
- Typically flat but pitched is possible
- Focus: vapour tightness warm side insulation.

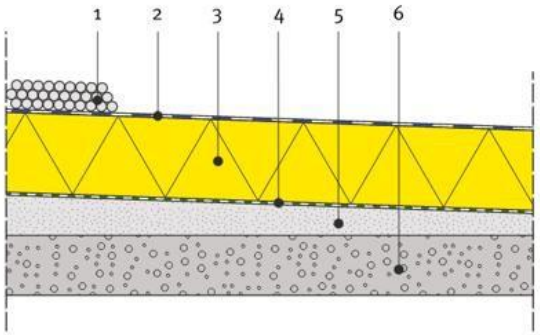
Flat roofs: avoid water at all times, no mechanics to recover !!!

Types of flat roofs



Warm roof

Green Roof



1. *Ballast (optional)*
2. *Water membrane*
3. *Insulation*
4. *Vapour barrier*
5. *Roof structure*

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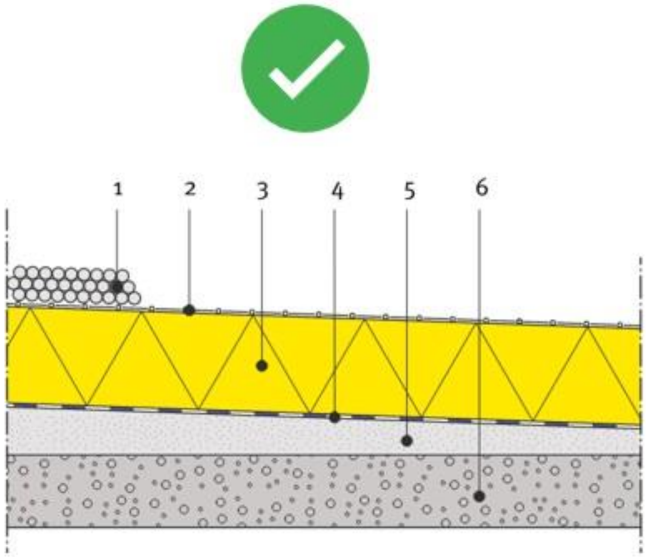
Types of flat roofs

Inverted roof (only XPS)



1. *Ballast*
2. *Mesh*
3. *Insulation*
4. *Water membrane (acts as vap. mem.)*
5. *Roof structure*

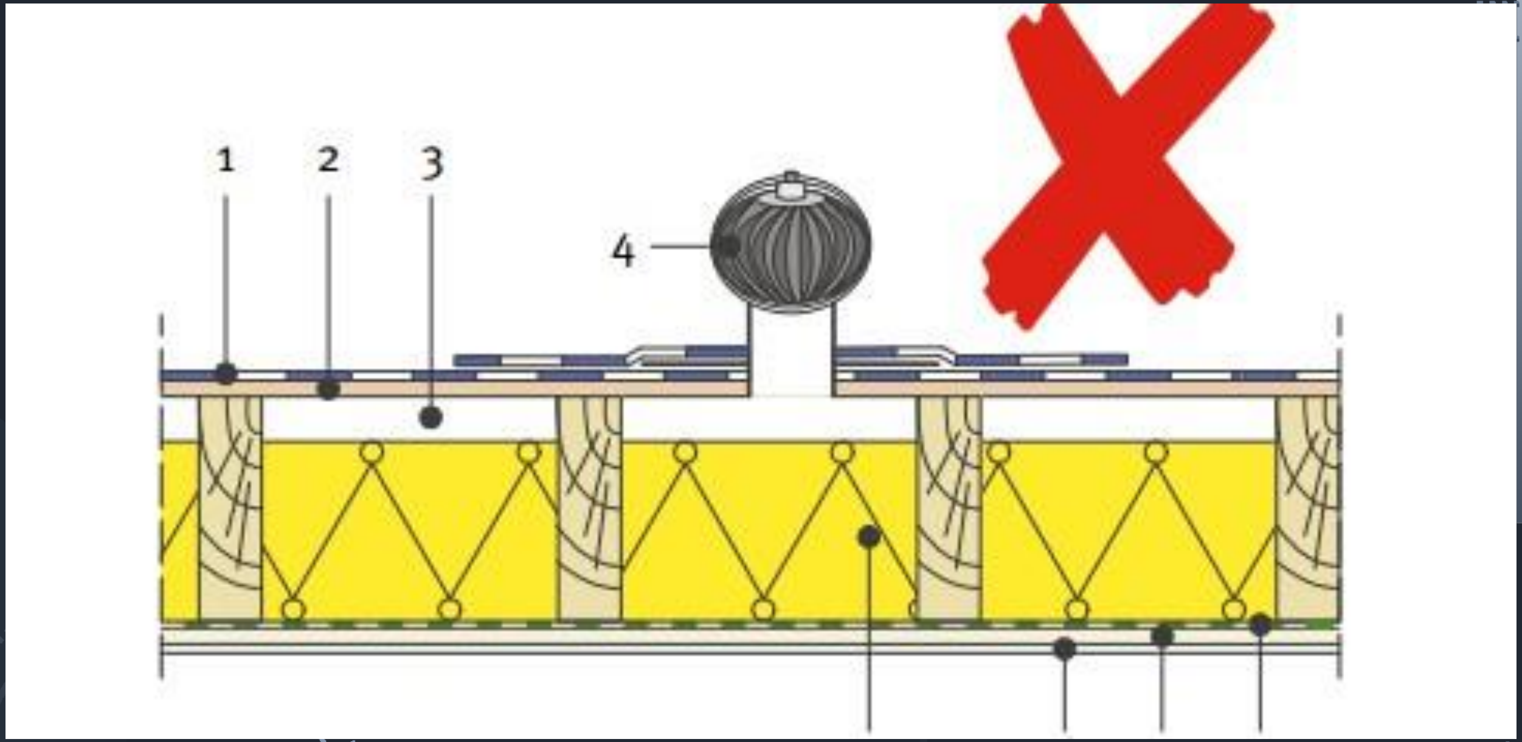
ASSESSING PRECIPITATION HEAT LOSSES OF PROTECTED MEMBRANE ROOFS

H.M. Künzel and K. Kießl

Fraunhofer-Institute of Building Physics
(Director: Prof. Dr.-Ing. habil. Dr. h.c. Dr. E.h.mult. Karl Gertis)

1. INTRODUCTION

Discussions about the amount of energy withdrawn from a building by precipitation penetrating the insulation layer of a protected membrane roof are as old as the protected membrane roof (also called inverted roof) itself. Due to higher demands concerning the heat energy consumption of new constructions this discussion has been intensifying in recent years. In order to determine the actual heat loss of such roofs under realistic conditions and with up to date insulation thickness investigations were carried out at the „HAMTIE-house“ in Holzkirchen whose results are summarised in this report.



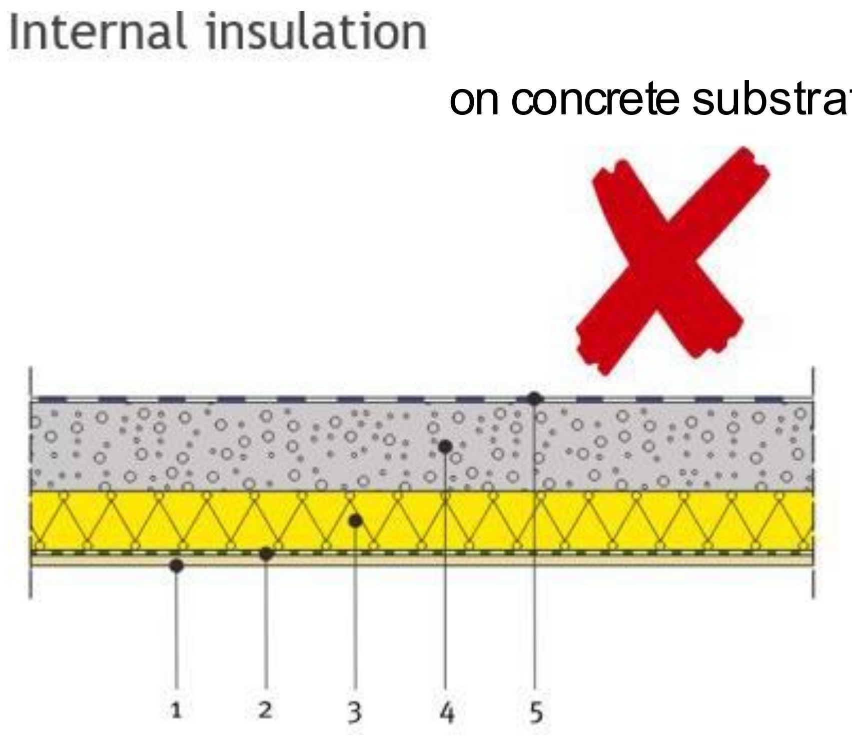
Types of flat roofs

- Condensation in winter: cold air has little absorption capacity
- Ventilation never enough to “dry” roof
- Possibly roof structure colder than air (steel)
- Ventilation creates under-pressure for internal air
- Efficiency insulation may reduce if wet -> snowball effect

Types of flat roofs

Problems:

- Expected interstitial condensation
- Green concrete dry-out time (25mm/month)
- Moisture pressure underneath roofing membrane

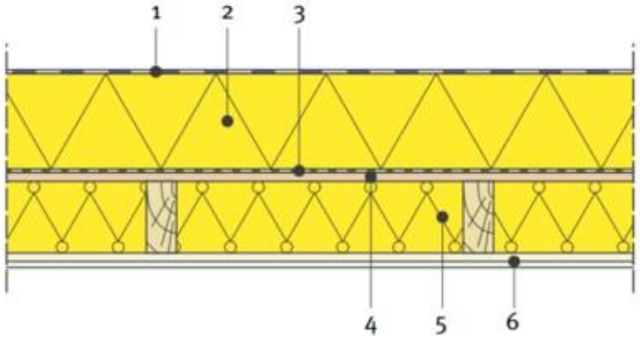


on concrete substrate

1. *Gypsum board*
2. *Vapour barrier*
3. *Insulation*
4. *Concrete*
5. *Membrane*

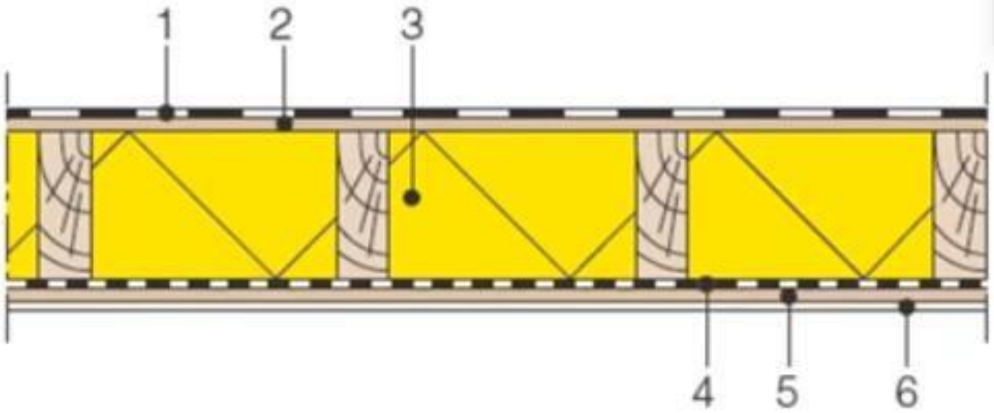
Types of flat roofs

- Insulation above AND below vapour



1 Membrane 2 Insulation
3 Vapour barrier 4 Carrier panel
5 Insulation 6 Internal lining

Types of flat roofs



COMPACT ROOF

1. Membrane 2. Plywood
3. Insulation 4. Vapour barrier
5. Plywood 6. Gypsum board

Vapour barrier

- Avoid internal condensation
- Reduce wind pressures on roof membranes
- Temporary waterproofing

Vapour barriers are classified by :

- E1: ≥ 2m and < 5m: PE
- E2: ≥ 5m and < 25m: glued thick PE
- E3: ≥ 25m and < 200m: APP, SBS bitumen
- E4: ≥ 200m: alu-faced bitumen, multi-layer bitumen

Vapour barrier – ISO 13788

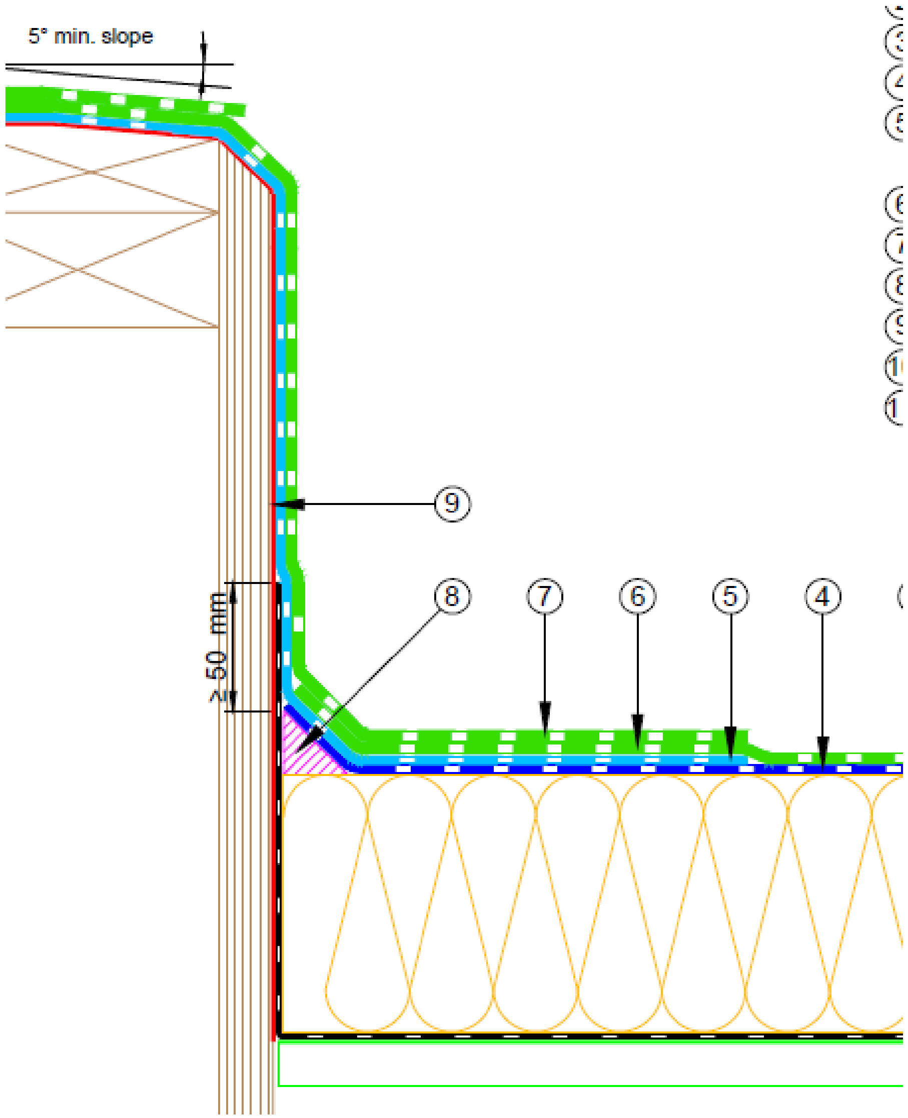
Humidity class	Building
1	Unoccupied buildings, storage of dry goods
2	Offices, dwellings with normal occupancy and ventilation
3	Buildings with unknown occupancy
4	Sports halls, kitchens, canteens
5	Special buildings, e.g. laundry, brewery, swimming pool

	Humidity class	PIR/XPS		MW	
		Mech	Glue	Mech	Glue
Concrete	2-3	E3	E3	E3	E3
	4-5	X	E4	X	E4
Timber/ plywood / steel	2	E1	E1	E2	E2
	3	E2	E2	E3	E3
	4-5	X	E4	X	E4

Vapour barrier

Careful detailing

- “Ziplock”



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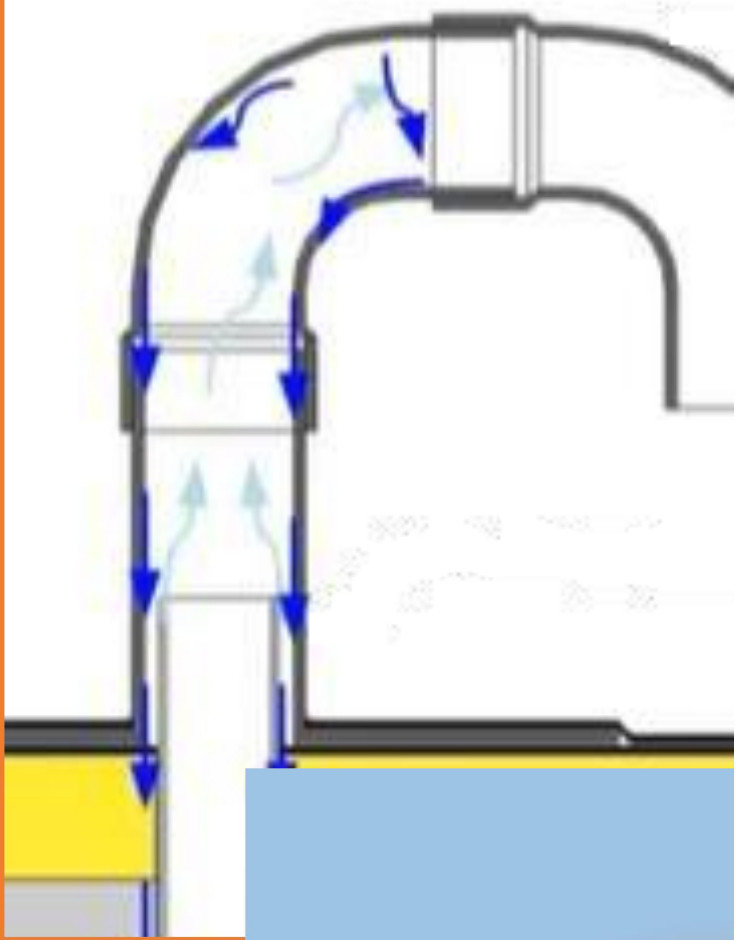
Vapour barrier

- Careful detailing

- Joints



Vapour barrier

Careful detailing

- Penetrations

Alternative Solutions

8.5 Membrane roofs and decks

8.5.1 Use and limitations

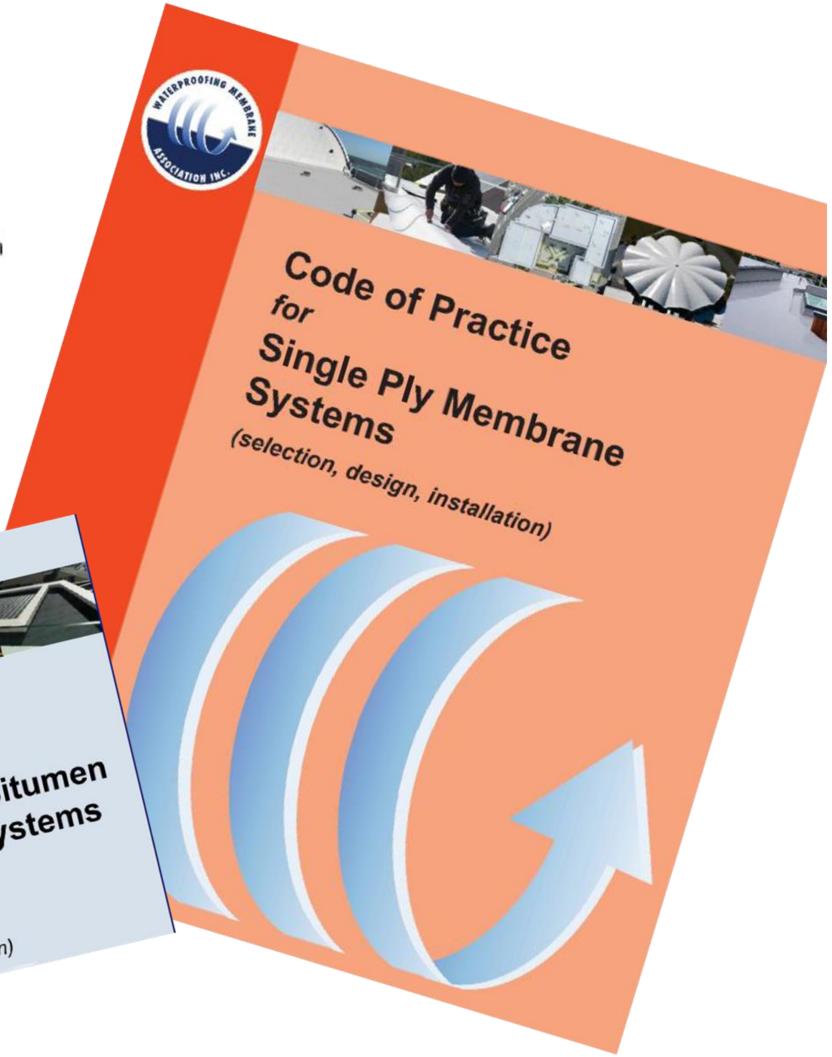
8.5.1.1 This section contains provisions for *membrane roofs* and *decks*.

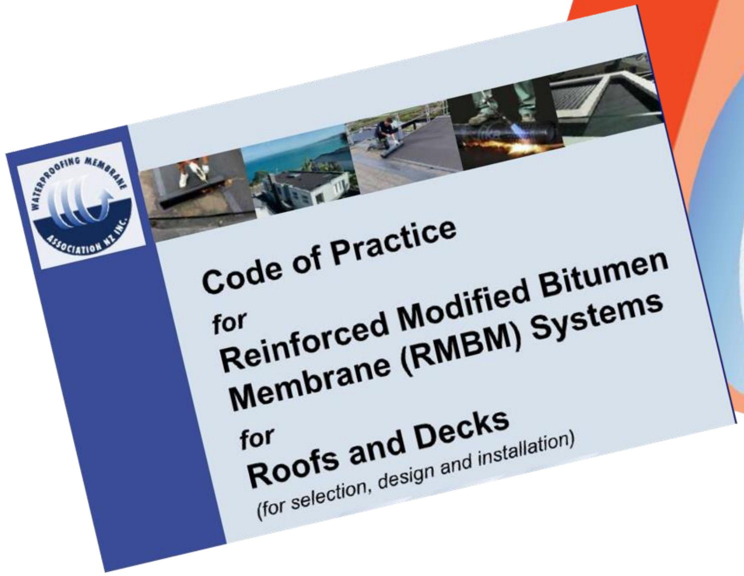
8.5.1.2 *Membrane roofs* shall be composed of butyl or *EPDM* installed over plywood substrates that have the following features:

a) *roofs* with a minimum fall of 2° (1:30); and

8.5.1.4 Closed-in *construction* spaces under *membrane roofs* and *decks* require adequate ventilation to prevent the accumulation of moisture under the membrane. Maintain a minimum gap of 20 mm between the underside of the substrate and any insulation, and for *membrane roofs* greater than 40 m^2, refer to manufacturer's details for *roof* cavity vents and/or substrate vent requirements.

- Other sources
  - WMAI
  - Branz





LCA

Typically aim for 60 years in 20 year cycles	
Bitumen	New layer every 20 years
Adhered thermoplastic and thermo-elastic	Replacement of membrane <u>and</u> insulation
Mechanical fixing: perforations needs repair	
Several recycling opportunities yet no NZ based plants	

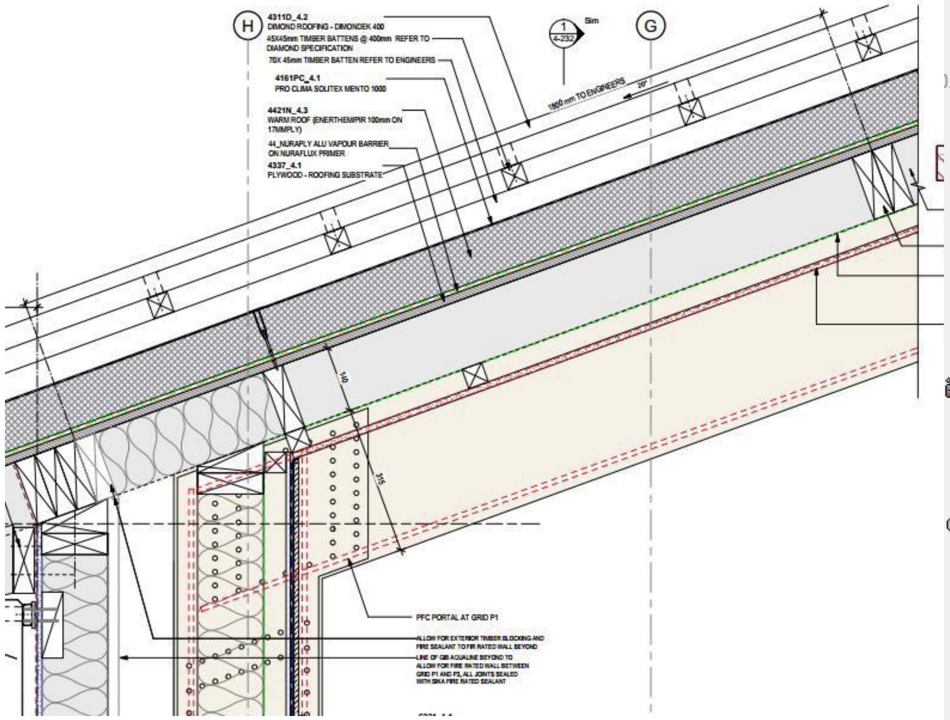
Pathology

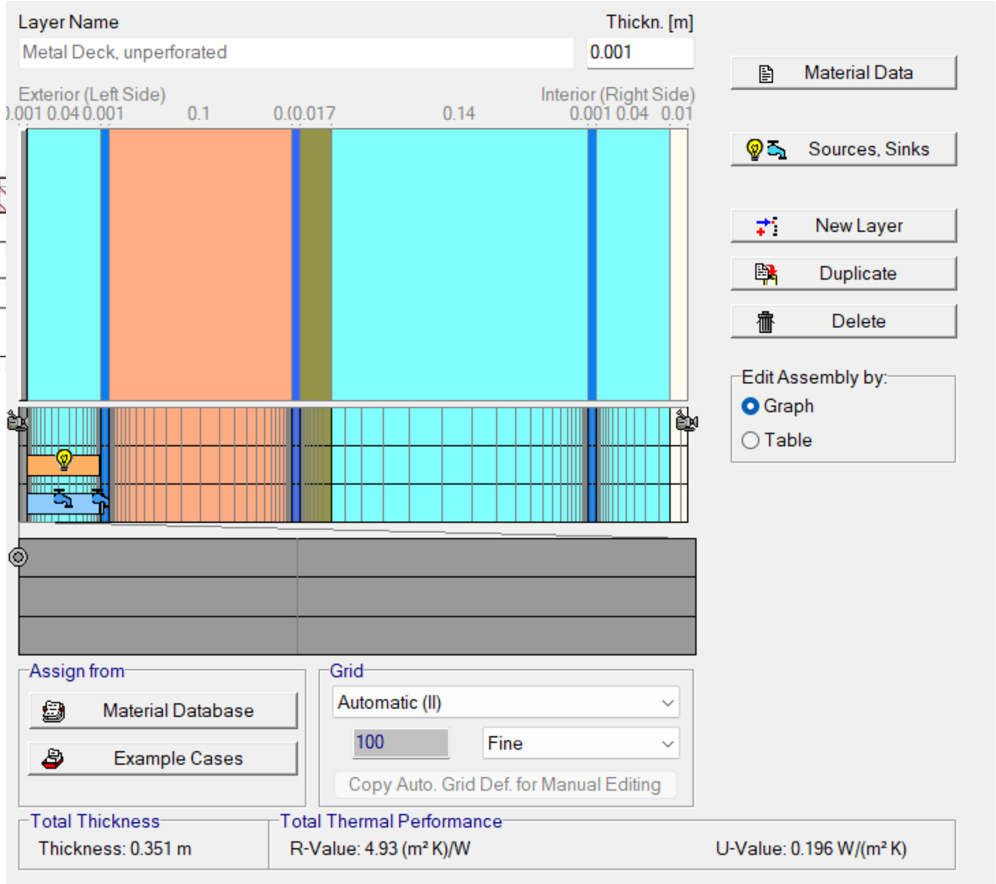
Example 1: concrete adhesion for adhered systems

- High moisture content in concrete
- Curing of concrete: too hot, frost
- Correct application primer
- Rain also after installation

Pathology

Example 2: double vapour barrier + timber product





Pathology

2 vapour barriers with enclosed timber product

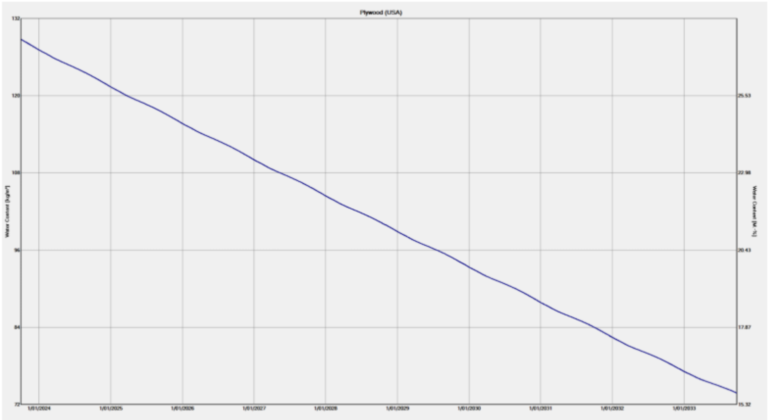
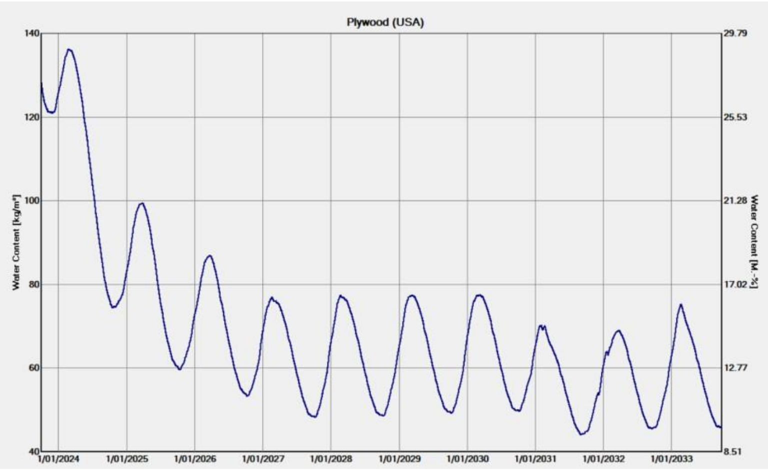
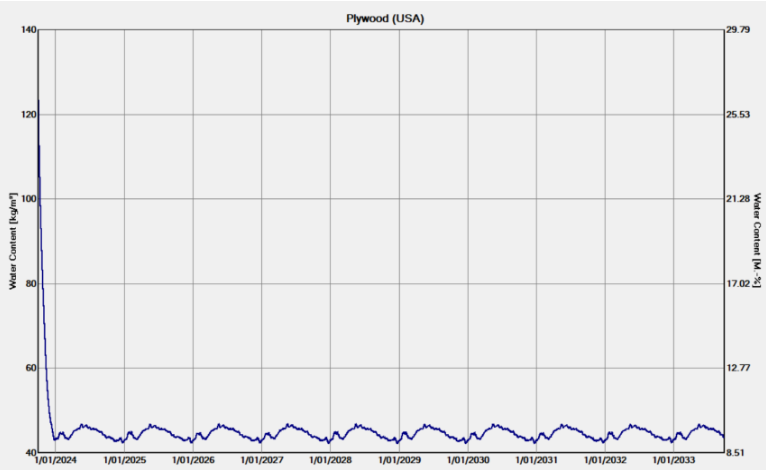


Figure: Moisture content in plywood sheathing





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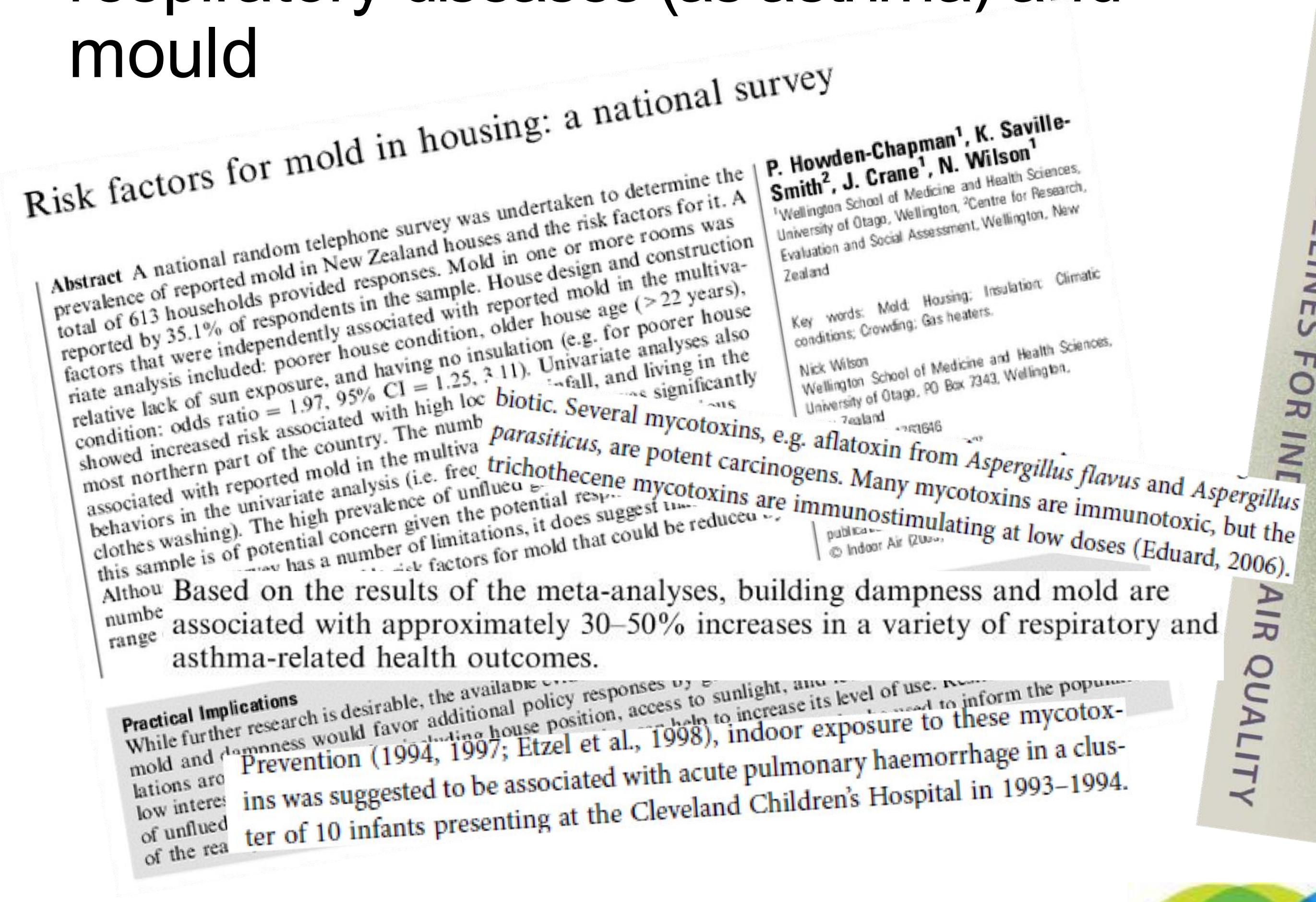
Effect of dampness and mould

- Significant correlation between respiratory diseases (as asthma) and mould



Risk factors for mold in housing: a national survey

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Key words: Mold; Housing; Insulation; Climatic conditions; Crowding; Gas heaters.

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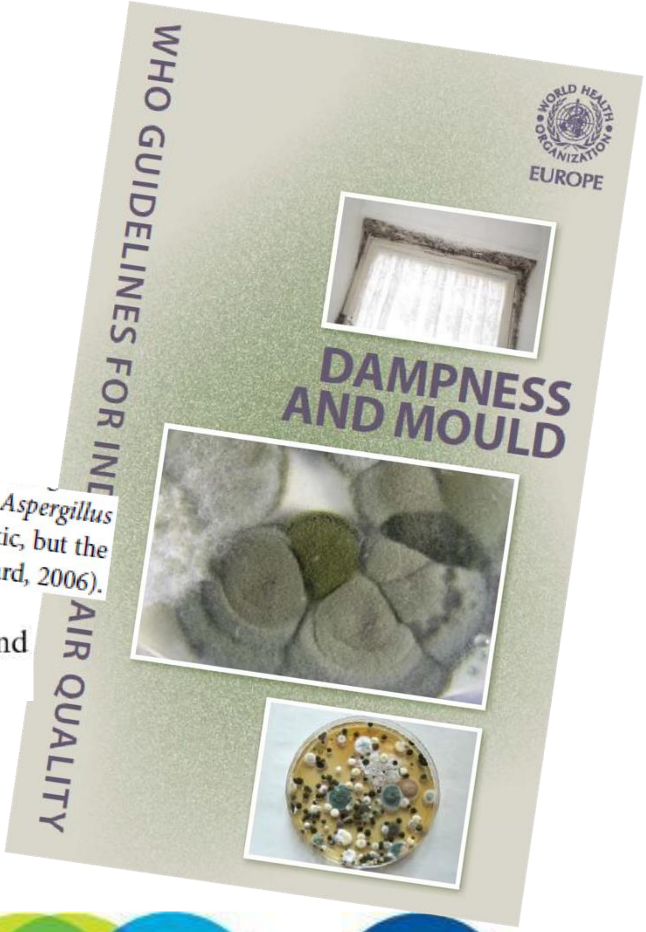
Abstract A national random telephone survey was undertaken to determine the prevalence of reported mold in New Zealand houses and the risk factors for it. A total of 613 households provided responses. Mold in one or more rooms was reported by 35.1% of respondents in the sample. House design and construction factors that were independently associated with reported mold in the multivariate analysis included: poorer house condition, older house age (> 22 years), relative lack of sun exposure, and having no insulation (e.g. for poorer house condition: odds ratio = 1.97, 95% CI = 1.25, 3.11). Univariate analyses also showed increased risk associated with high loc ... fall, and living in the most northern part of the country. The numb ... significantly associated with reported mold in the multiva ... behaviors in the univariate analysis (i.e. freq ... clothes washing). The high prevalence of unflued ... this sample is of potential concern given the potential resp ... it does suggest ... risk factors for mold that could be reduced ...

biotic. Several mycotoxins, e.g. aflatoxin from *Aspergillus flavus* and *Aspergillus parasiticus*, are potent carcinogens. Many mycotoxins are immunotoxic, but the trichothecene mycotoxins are immunostimulating at low doses (Eduard, 2006).

Based on the results of the meta-analyses, building dampness and mold are associated with approximately 30–50% increases in a variety of respiratory and asthma-related health outcomes.

Practical Implications
While further research is desirable, the available ... policy responses ... mold and dampness would favor additional policy responses ... access to sunlight, and ... house position, ... help to increase its level of use. ...

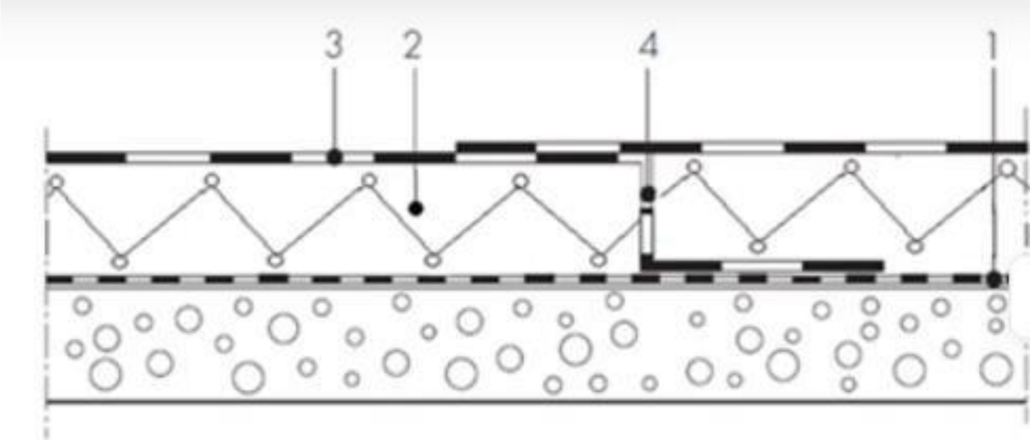
Prevention (1994, 1997; Etzel et al., 1998), indoor exposure to these mycotoxins was suggested to be associated with acute pulmonary haemorrhage in a cluster of 10 infants presenting at the Cleveland Children's Hospital in 1993–1994.



Safety nets

Compartmentation

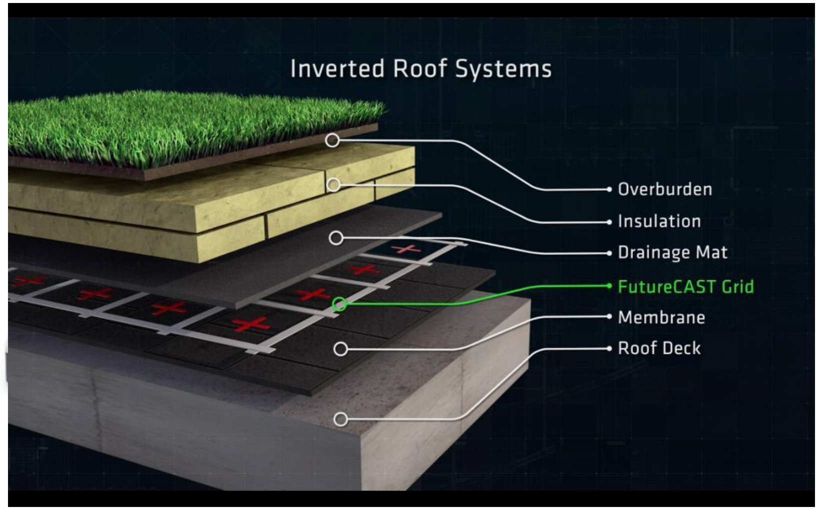
Specifications + AS BUILTS



Sensors in compartments

20+ years

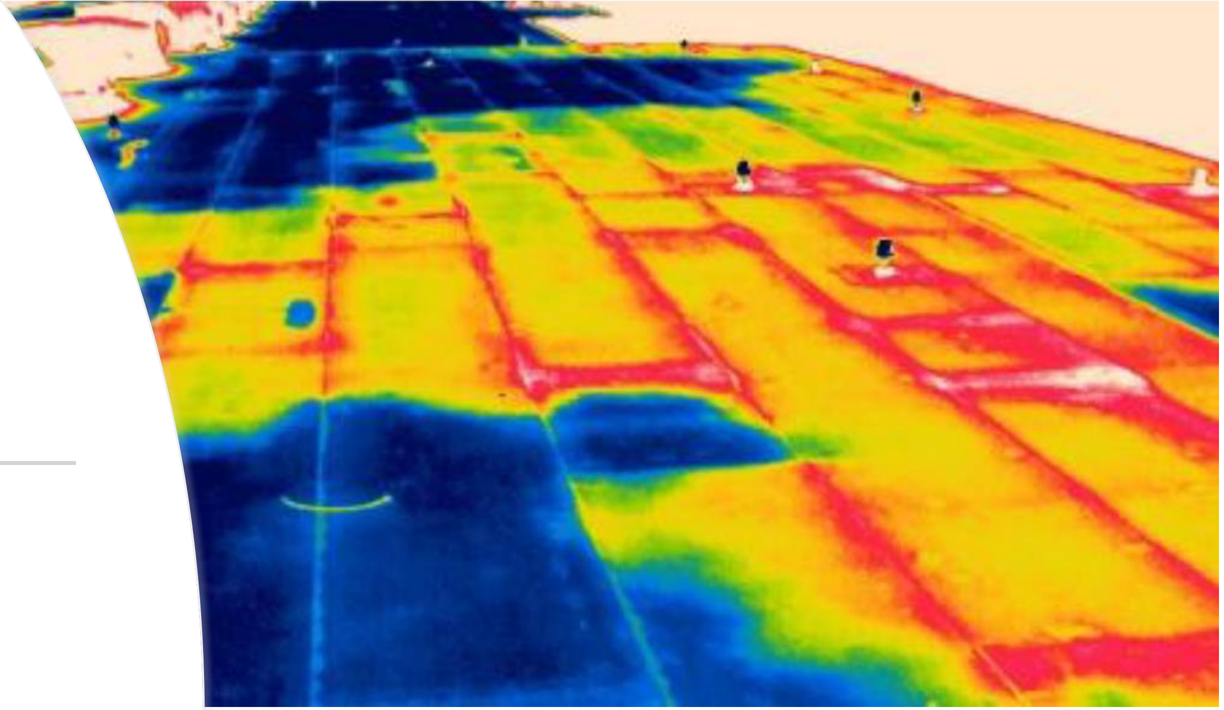
Predictive comparative model

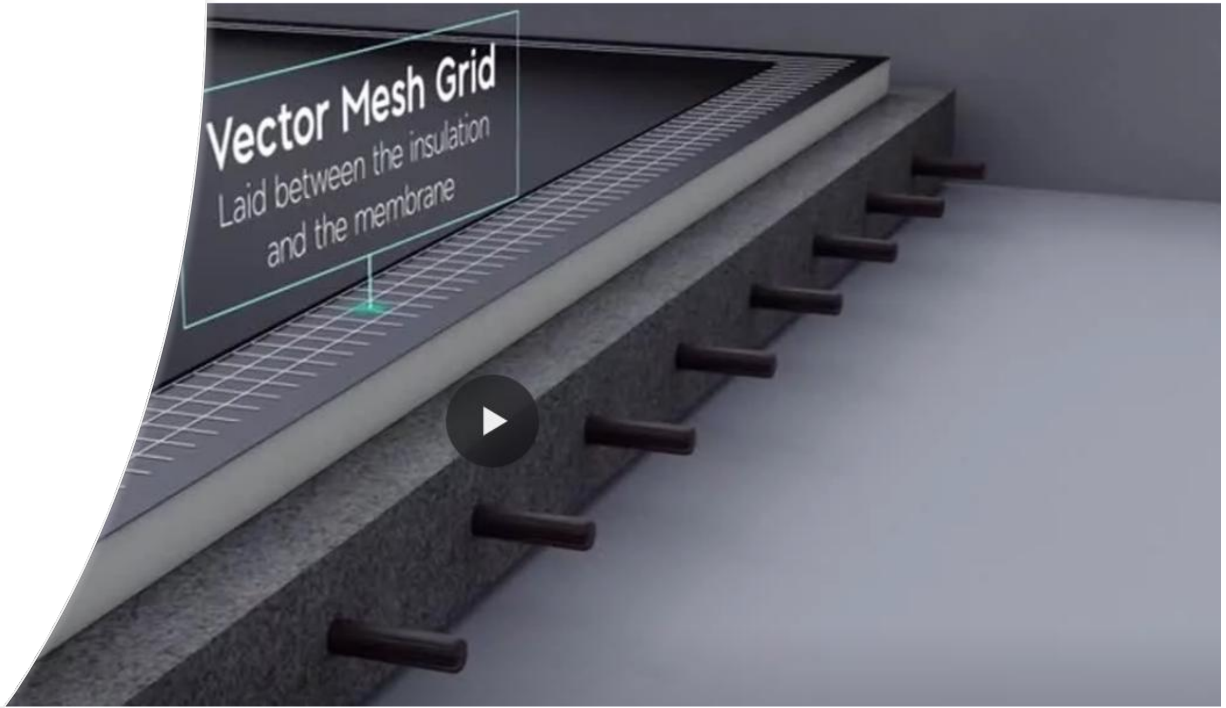


Safety nets

- IR imaging (end of first winter?) Babbage drone

- Electronic Leak Detection





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