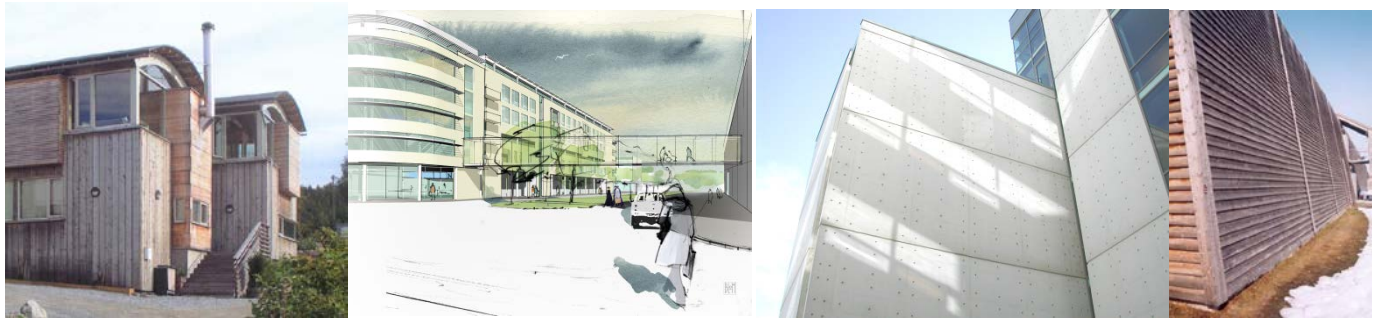
Moisture and building physics in research and practice

- some Norwegian experiences from the last 10 years



Stig Geving, prof./consultant
Norwegian University of Science and Technology, Trondheim
Sweco Norway

NTNU
Det skapende universitet

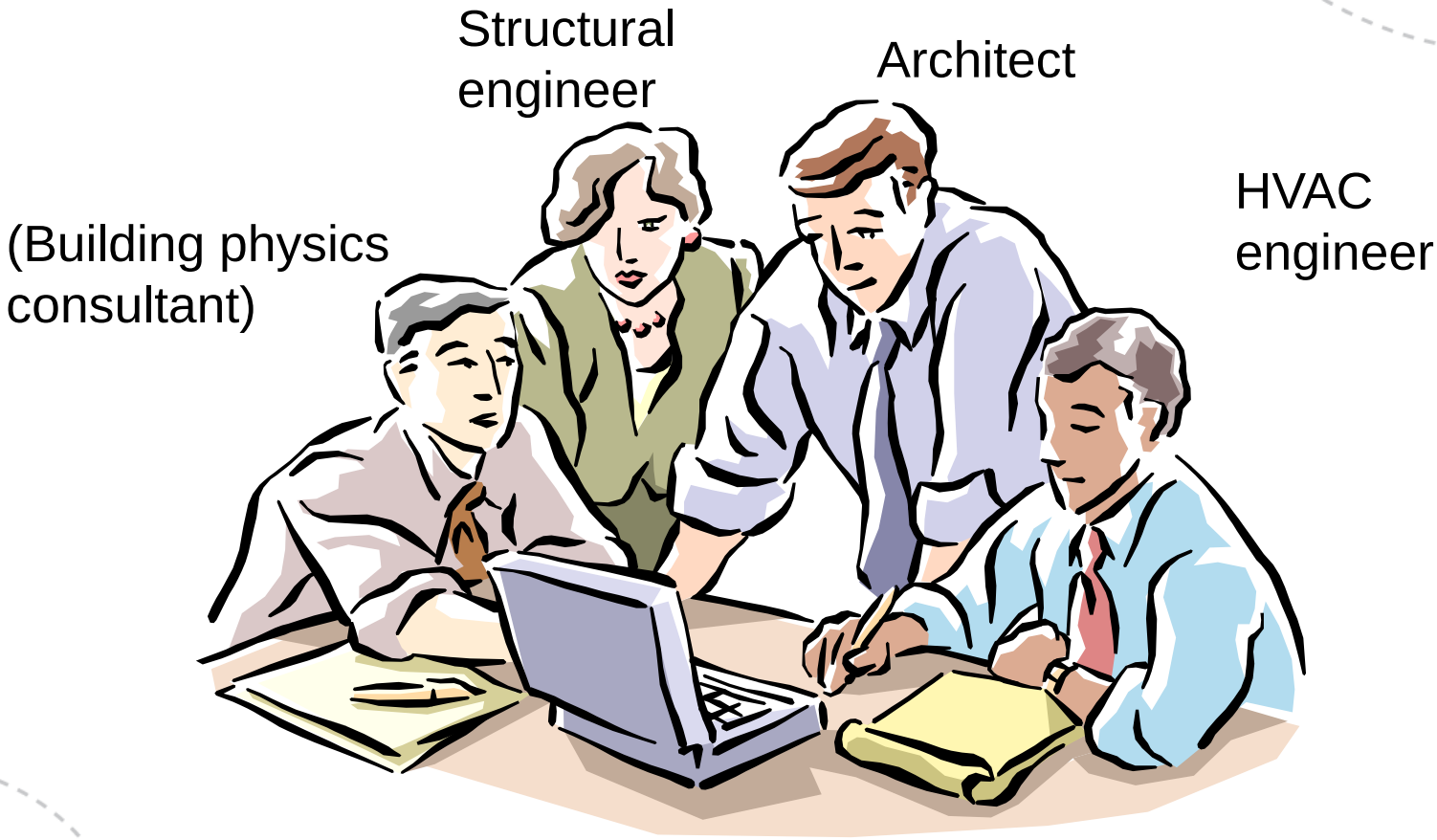
PRACTICE

(WITH FOCUS ON BUILDING PHYSICAL DESIGN PROCESS)

Building physical design process –

> 10-15 years ago

= not much focus on building physics in most projects

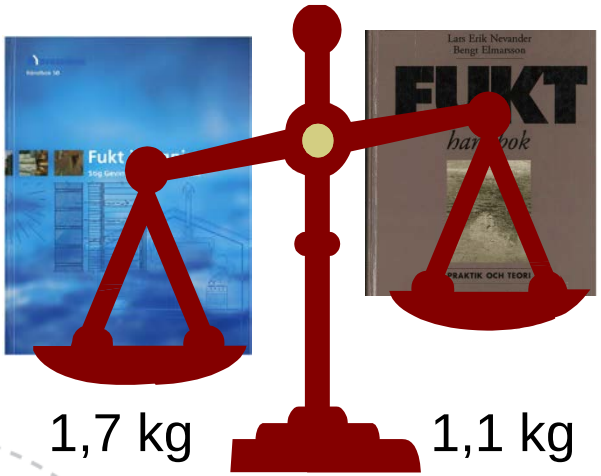


But changes were to come……, slowly……..

www.sintefbok.no

Moisture handbook

- Published 2002



National moisture seminar

- Yearly since 2002
- Focus on moisture damages, mould growth, water damages etc

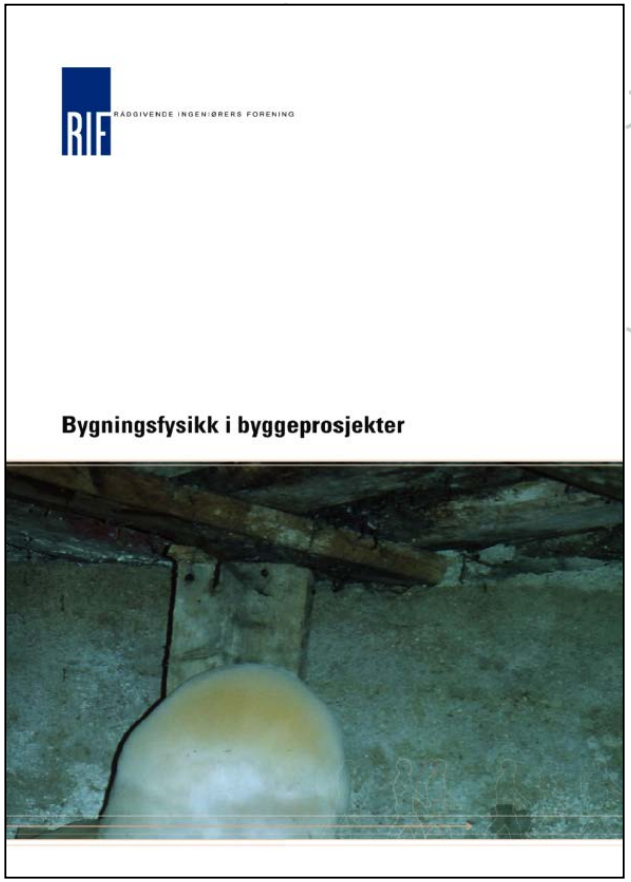
Norwegian Building Physics Day

- Yearly since 2005
- 140-180 participants
- Moisture and energy (building envelope)
- Focus on avoiding moisture problems
- www.bygningsfysikk.no

2008:
First NORM for **B**uilding **P**hysics (BP) design

- Defined:
  - Necessary competence
  - Typical tasks for consultant
  - Contractual responsibilities
  - Phases during the project
  - Deliverables, documentation

- Defined – What is BP?
  - Heat transfer
  - Air transfer
  - Moisture transfer
  - Material use



Tasks and responsibilities – table from norm

Overall framework conditions:

RIByfy = Rådg. Bygningsfysikk ARK = Arkitekt RIB = Rådg. Byggeteknikk RIV = Rådg. VVS RIE = Rådg. Elektro

Oppgave	RIByfy	ARK	RIB	RIV	RIE
Identifisere og fastsette overordnede rammebetingelser og forutsetninger					
Definere bygningens bruk og virksomhet		H			
Definere arealer		H			
Klargjøre og definere inneklima og inneklimasoner (temperatur- og fuktforhold)	M	M		H	
Klargjøre og definere uteklima (temperatur-, fukt- og solforhold)	M	M		H	
Definere klimaskiller/klimaskall	M	M		H	
Definere konstruktive løsninger, bæresystem, innfestinger	M	M	H		
Definere prinsipper for fasadeutforming	M	H	M		
Definere våtsoner og våtrom	M	H	M	M	
Definere mulige fremtidige forandringer i bruk av arealer som har bygningsfysisk betydning (premiss i prosjektet)	M	H	M	M	

Thermal insulation/energy use:

Oppgave	RIByfy	ARK	RIB	RIV	RIE
Varmeisolering/energibruk					
Vindusareal	M	H		M	
Varmeisolasjonstykkelser i vegger, tak, gulv, terrassegulv, konstruksjoner mot terreng og mot uoppvarmede rom	H	M	M		
Varmeisolasjonstykkelser i skillekonstruksjoner mellom forskjellige klimasoner	H	M			
Varmeisolasjonsmaterialer/-kvaliteter	H	M			
Plassering av varmeisolasjonssjikt	H	M			
Vurdering av kuldebroer	H	M			
Valg av glass og karm/rammer/profiler i vinduer, glassfasader og glasstak	M	H		M	M
U-verdiberegning	H	M			
Areal- og varmetapsberegning	H	M			
Energiberegning	M	M		H	M
Temperatur- og varmeberegninger i konstruksjoner	H	M			
Sol-/skyggeforhold, solskjerming og reflekser	M	H		M	M
Frost-/telesikring	M	M	H		

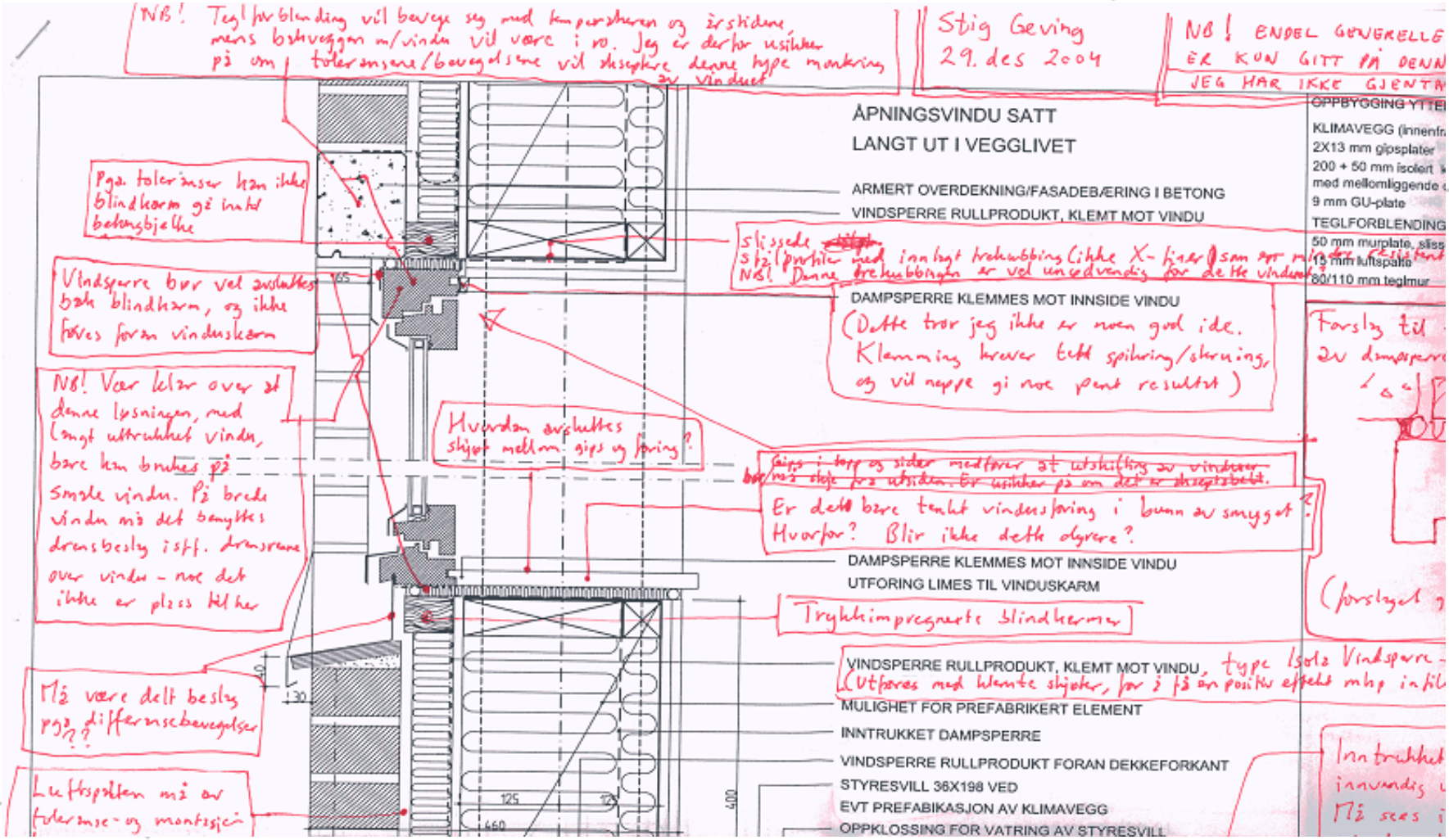
Moisture:

Oppgave	RIByfy	ARK	RIB	RIV	RIE
Fukt					
Definere utførelseskrav i beskrivelse til fuktsikker bygging	H	M	M	M	
Assistere byggherre – utarbeide rutiner, sjekklister for kontroll av utførelse	H	M		M	
Fuktprosjektering/-kontroll i grensesnitt mot andre prosjekterende	H	M	M	M	M
Byggfukt – materialkondisjonering, byggerekkefølge, beskyttelse, tørketid	H	M	M		
Avvanning av tak – fall, sluk og nedløp	M	H	M	M	
Avvanning av gulv – fall og sluk	M	H	M	M	
Korrosjons-/miljøklasser	M	M	H		
Dampsperre i klimaskillende konstruksjoner (tilslutninger, gjennomføringer og skjøter)	H	M			
Fukt-/kondensberegninger	H	M			
Membran på vegg og gulv inkl. oppkanter, tilslutninger og gjennomføringer	H	M		M	
Lim og fugemørtler, flisfuger	H	M	M		
Rom og ytterkonstruksjoner under terreng	M	M	H		
Drenering av ytterkonstruksjoner	H	M	M		
Fuger i gulv, flisfuger	M	H	M		
Konstruksjonstilslutninger, sammenføyninger og detaljer – fuger, beslag	M	H	M		
Utendørsanlegg – avvanning, drenering	M	M		H	
Drenerende masser, kapillærbryting	M	M	H		
Frostbestandighet	H	M	M		
Sanitærinstallasjoner	M	M		H	

Main deliverables

- Premise report on building physics
  - relevant regulatory requirement, functional requirements, special project premises, main solutions and material use
- Control of arcitects detail drawings
- Calculation of U-values
- Thermal bridge values
- Ad-hoc councelling
  - Ex: slope, drainage roof, facade principals, insulation thicknesses, material use, height of parapets, tender documents, production phase
  - Moisture simulations

Control detail drawings – most important activity?



Latest 3-5 years – increasing demand; more deliverables & projects

- Detailed energy simulations
  - previous HVAC-designers responsibility
- Daylight simulations
  - Previous architect or Electro-engineer
- BREEAM-analyses, LCA
- Indpendent control of building physics design and executon

INDEPENDENT CONTROL (2013)

MANDATORY independent control on:

- Structural safety
- Geotechnics
- Fire safety
- **Moisture safety and building physics**

- For DESIGN & EXECUTION PHASE
- **For ALL building projects!!!**

- Purpose:reduce number of building damages/faults

Independent control - DESIGN

- QA-system
- Routines for building physics design
- Documentation of QA (signed checklists)
- Energy efficiency (simple control documentation)
- Moisture safety:
  - Control a few important detail drawings (Vapour/wind barrier, roof membrane, terraces)

Independent control - EXECUTION

- Smaller houses/dwellings:
  - Control of WETROOMS (membrane …)
  - Control air-tightness measurement report – OK?
- Larger buildings:
  - Control selected building details is according to drawings
  - Check that wood moisture is measured before closure
  - Control air-tightness measurement report – OK?
  - Control ventilation air volumes is according to Energy simulations

  - Contractors QA system + examples of signed checklists
  - Drawing lists
  - Relevant routines
  - Drawings and material documentation available at building site

Independent control

Does it function according to purpose?

YES & NO

- Mostly control of QA-system, routines etc
- Not enough time to find (the important) errors/faults
- Competence of controller?

- Leads to more focus on BP-design!
- Consultant firms control each other – and learn….
- Improved routines in design/execution due to control

RESEARCH (EXAMPLES WITH FOCUS ON MOISTURE)

Who is active in moisture research?

- SINTEF
  - Trondheim + Oslo
  - Also dominating position on INFORMATION
- Norwegian University of Science and Technology (NTNU)
  - Trondheim
- Some smaller companies:
  - Mycoteam (mould, moisture damages etc)
  - Etc

Large research programs focusing on moisture

- *Moisture in buildings (1993-1997)*
- Climate 2000 (2000-2006)
- Climate Adapted Buildings (2007-2011)
- ROBUST (2008-2012)
- Climate 2050 (2015-2022)
- + many smaller projects

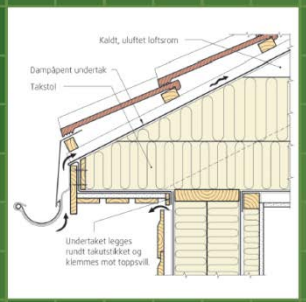
www.sintefbok.no

New construction principal:
Unventilated cold attics – risk for condensation

PETER BLOM OG TROND BØHLERENGEN

Kondensfare uluftede loft
Feltundersøkelse

Prosjektrapport 108 2012

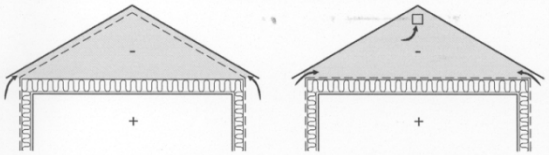


SINTEF

Sivert Uvsløkk

Tak med kaldt loft

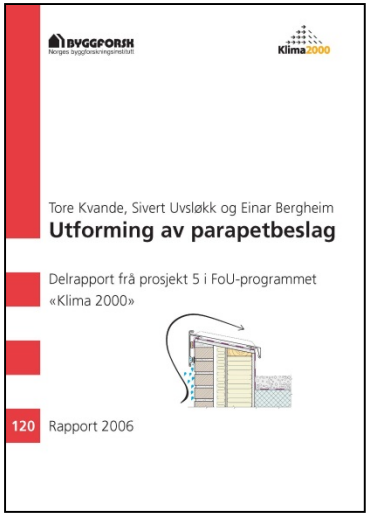
Delrapport fra prosjekt 4 i FoU-programmet «Klima 2000»



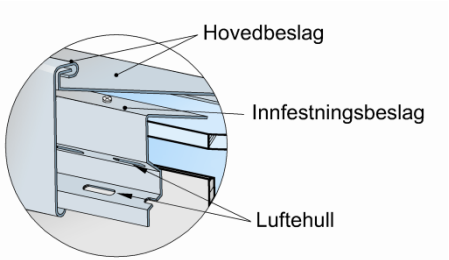
396 Prosjektrapport 2005

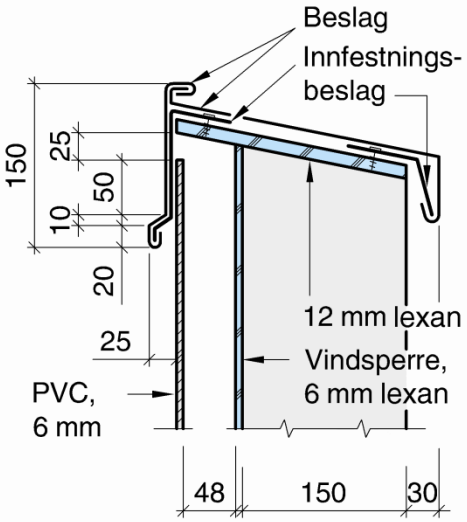
Flashings against rain

- Laboratory tests of rain tightness of various flashing geometries

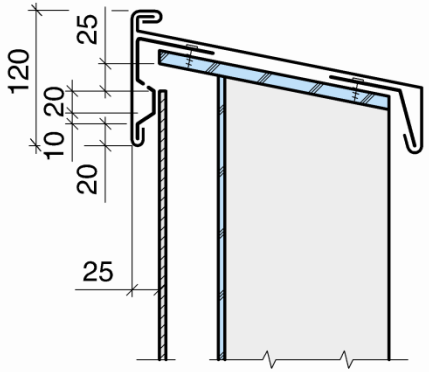


Driving rain test for parapet flashings





2.1.2



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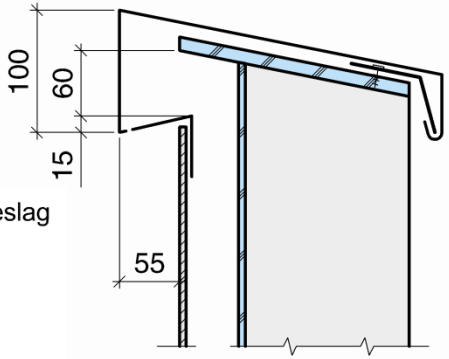

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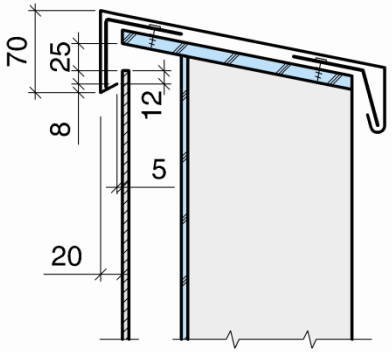

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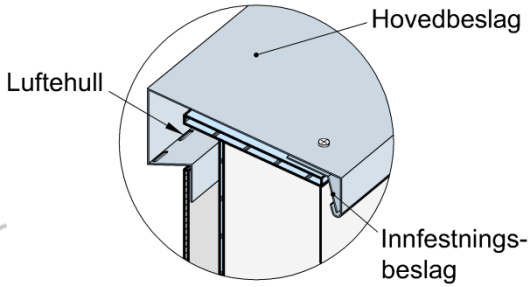


Wooden claddings and driving rain

- Climate adapted wooden claddings
- Measured driving rain on facades
- Effect of driving rain load, ventilation openings, surface treatment etc.

SINTEF Byggforsk

TORE KVANDE, KIM ROBERT LISØ OG BERIT TIME

Luftede kledninger

Klimapåkjenninger, erfaringer og anbefalinger

BYGGFORSK
Norwegian Building Research Institute

Climate2000

Stig Geving, Tore Henrik Erichsen,
Kristine Nore and Berit Time

Hygrothermal conditions in wooden claddings

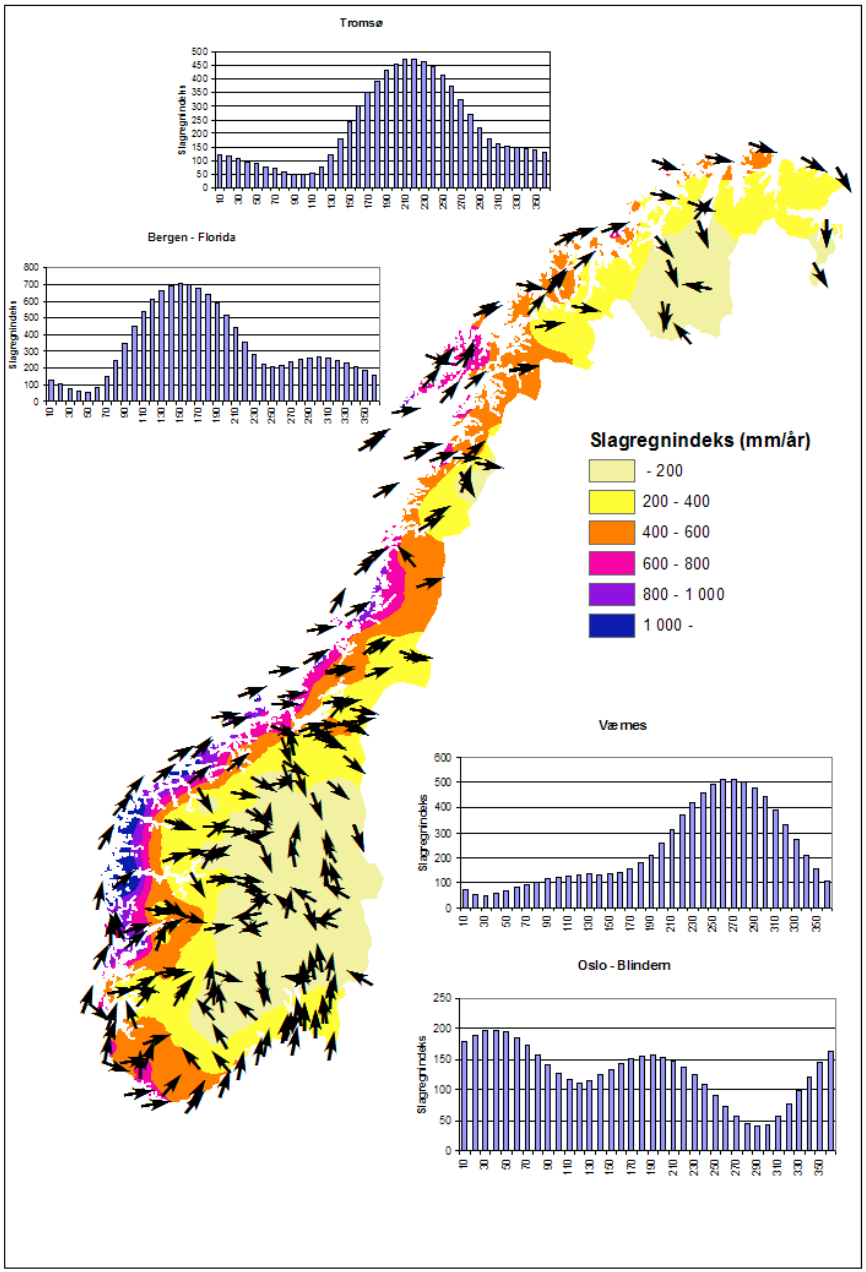
Test house measurements

Report from the R&D-programme «Climate 2000»

407 Project report 2006

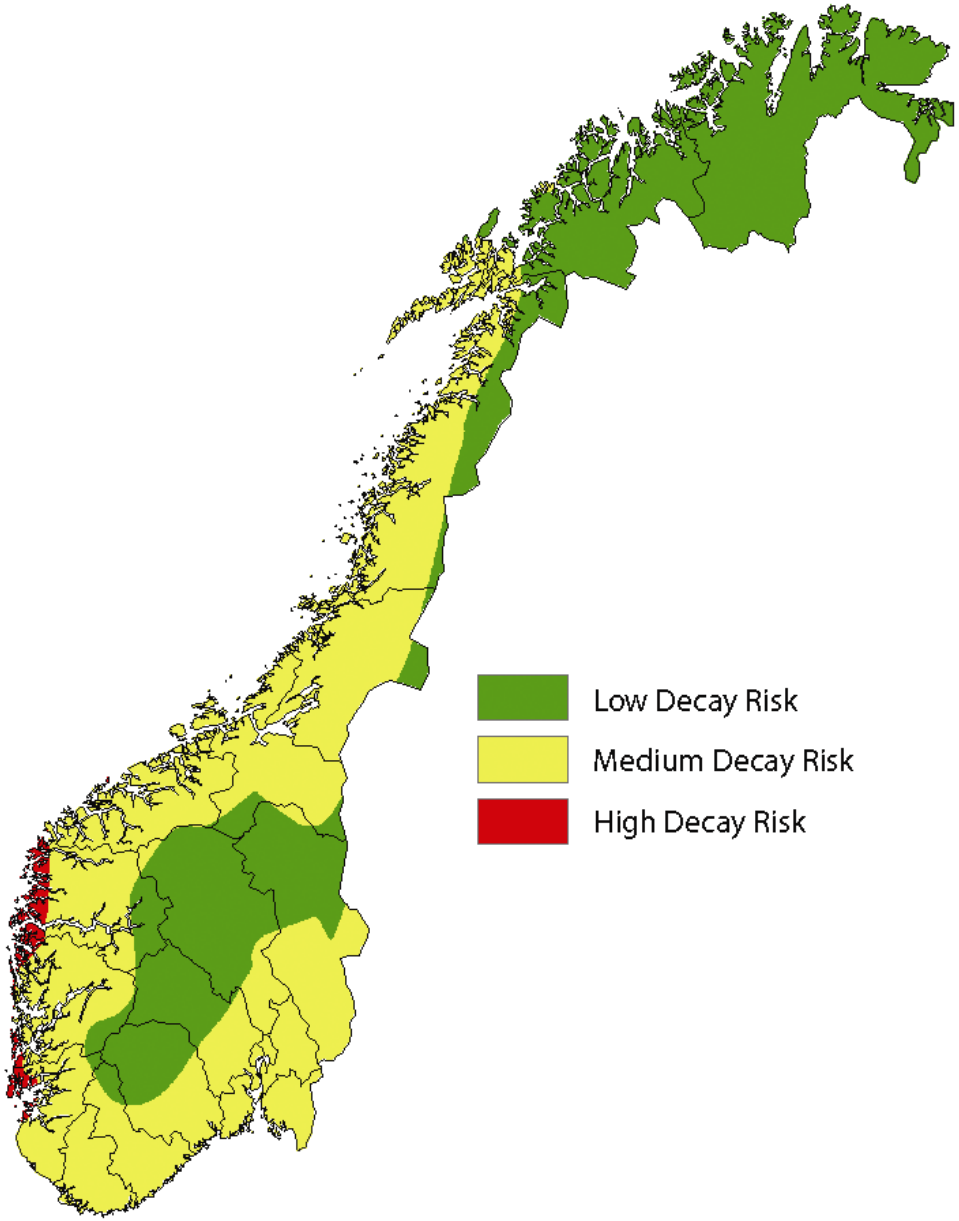
New driving rain map for Norway

- Developed in cooperation with Norwegian Meteorological institute

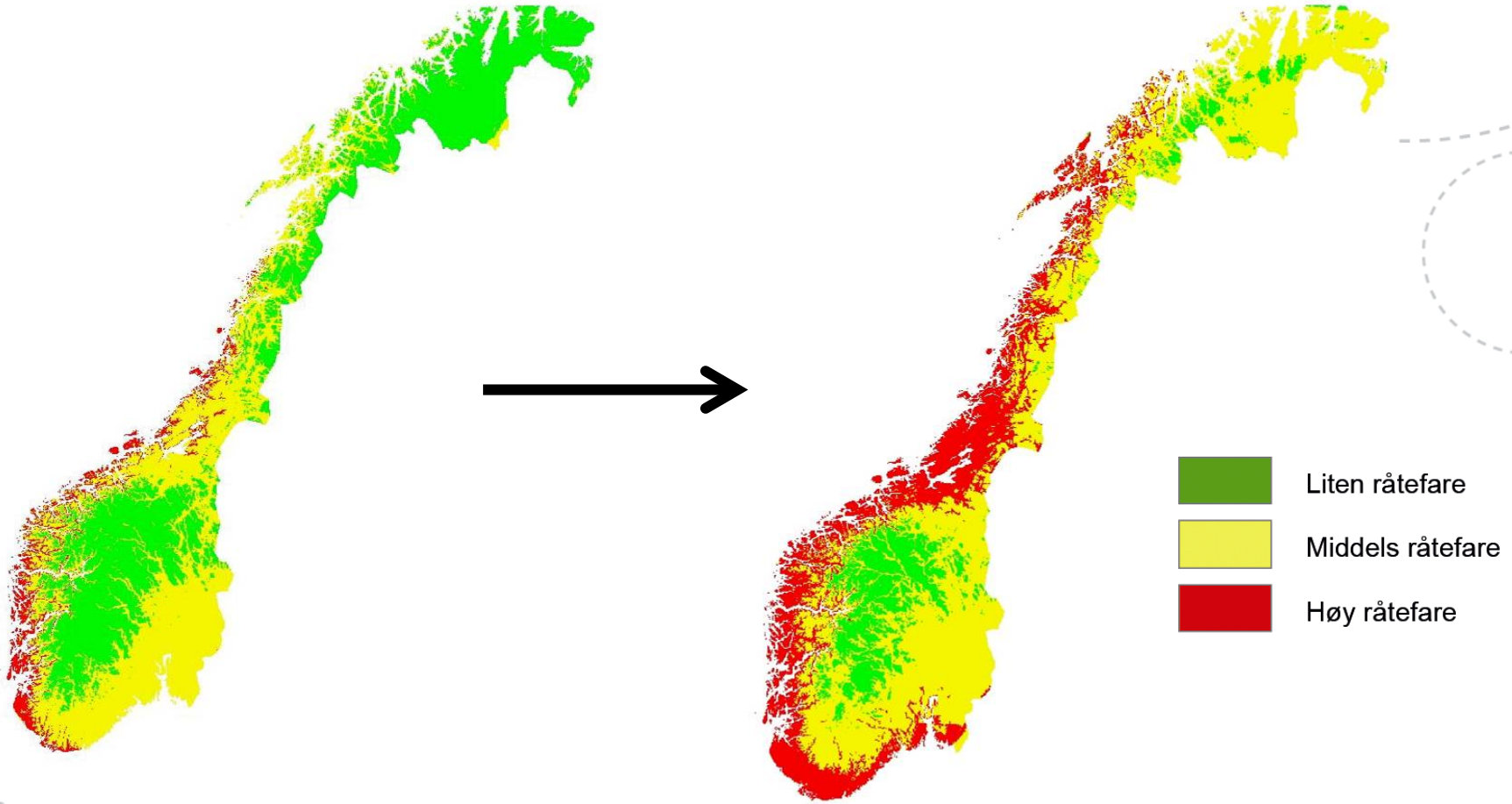


Rot index

- Scheffers rotindeks.
- Index based on data of temperature and moisture, and growth rate for rot fungi
- Used for dividing in climate zones e.g. for wooden claddings and surface tratments.



Rot index – effect of a changing climate

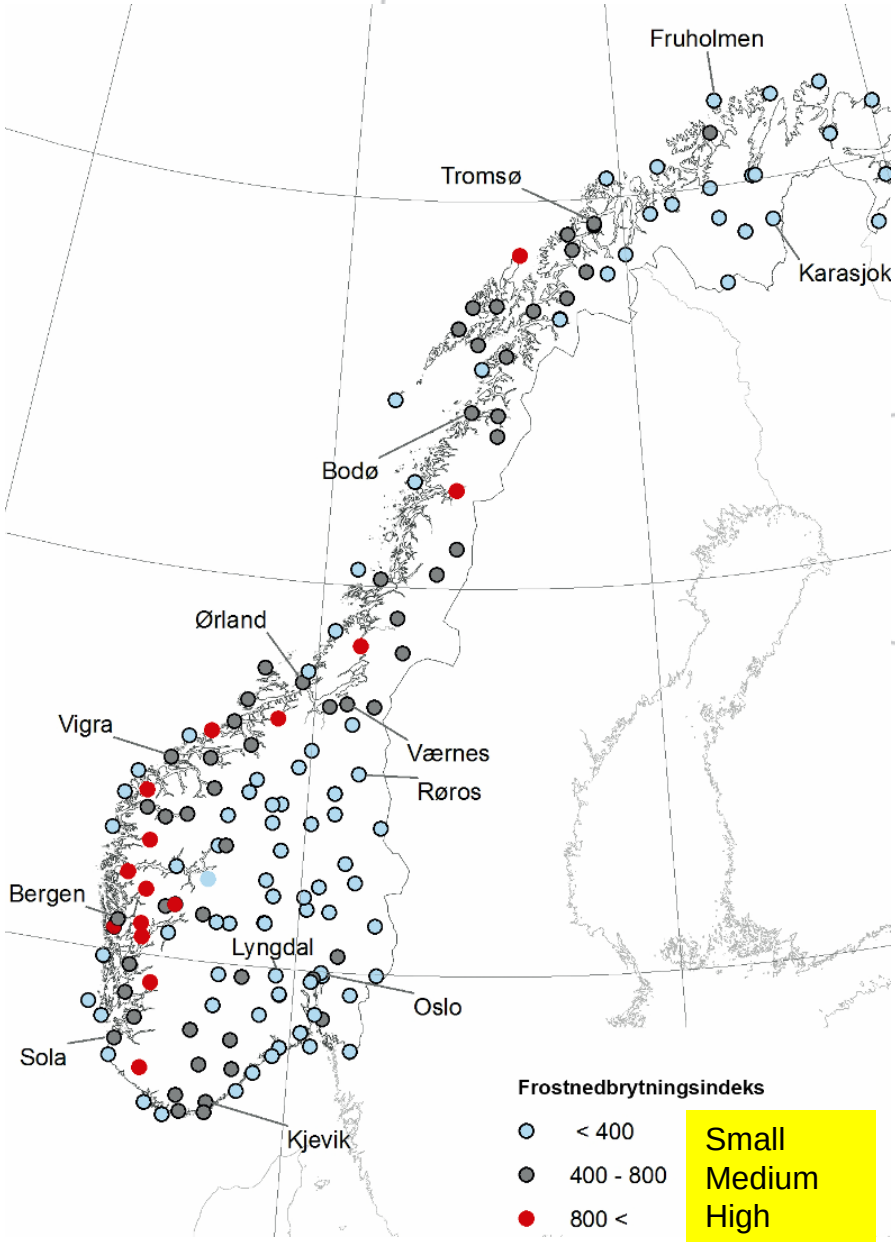


1961-1990

2021-2050

Frost decay index

- Rain load previous to freezing
- Coupling of climatic load, materila behaviour and damage experiences



Drying of moisture in concrete

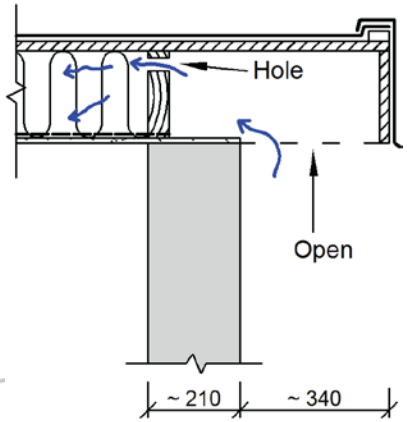
Compact roofs

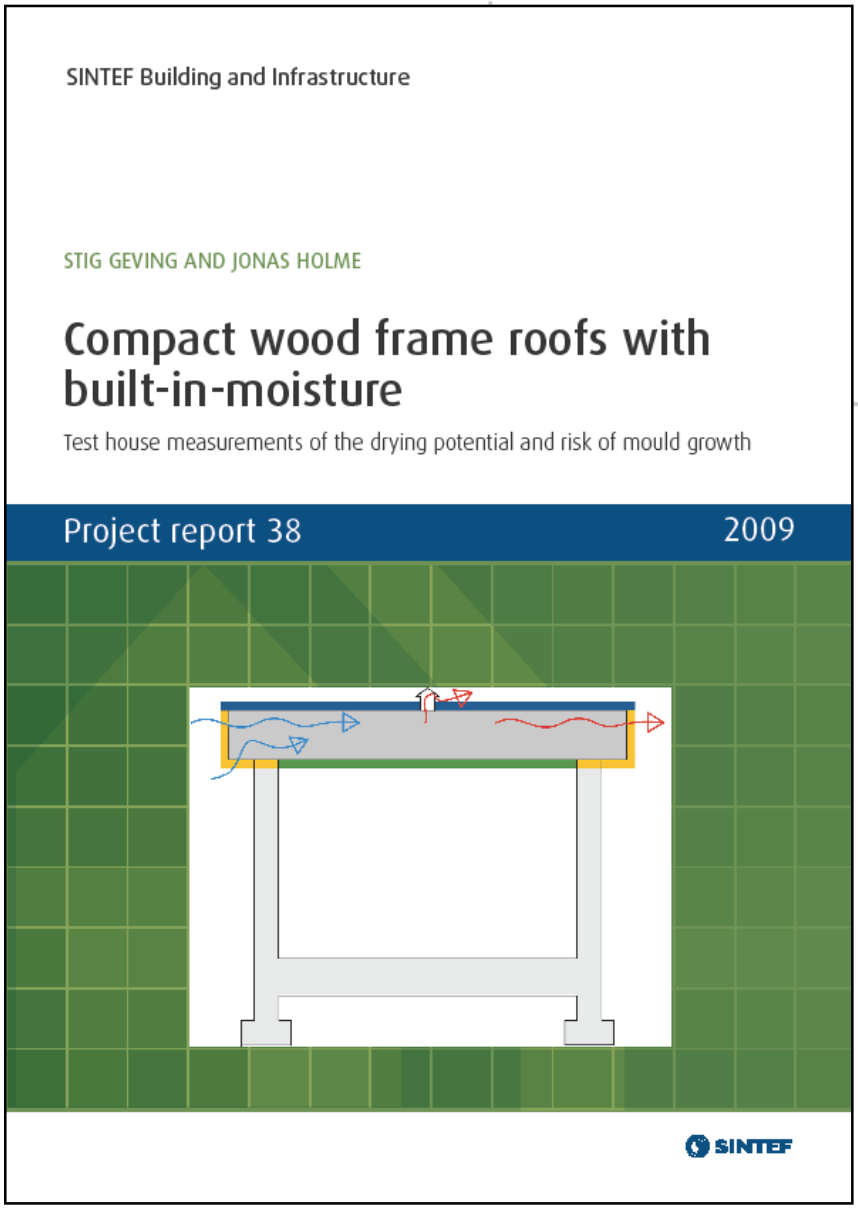
Self-drying mechanisms

Built-in-moisture and mould in compact roofs

- Moisture and mould measured in 12 wet compact roofs in 2002, with follow up in 2004 and 2007.
- Self drying effect found
- Drying mechanisms mapped


Instrumented
Instrumented
Instrumented
Field number
Growth rate
Ventilation gap
Paint type
W7-N Fast 23 B
W7-S Slow 23 B
W6-N Fast 4 A
W6-S Slow 4
W5-N Fast 4 B
W5-S Slow 4 B
W4-N Fast 0 B
W4-S Slow 0 B
W2-N Slow 23 A
W2-S Slow 4 A
W1-N Slow 0 A
W1-S Fast 0 A


Hole
Open
~ 210
~ 340

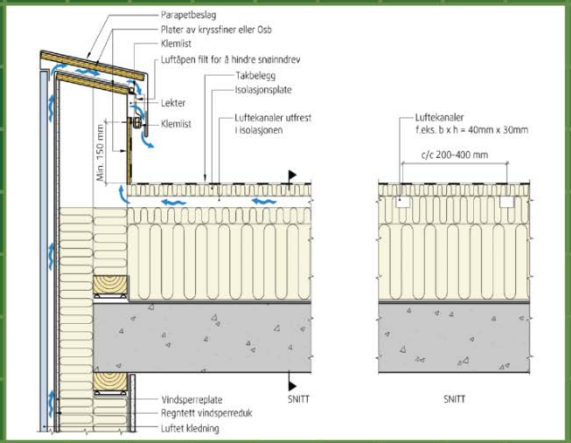

SINTEF Building and Infrastructure
STIG GEVING AND JONAS HOLME
Compact wood frame roofs with built-in-moisture
Test house measurements of the drying potential and risk of mould growth
Project report 38
2009
SINTEF

Use of ventilation “channels” in compact roofs

KNUT NORENG OG SIVERT UVSLØKK

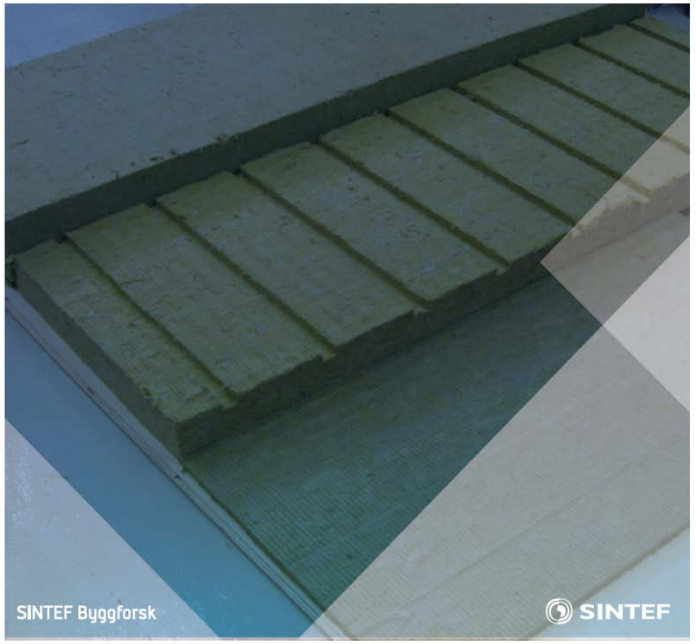
Robuste kompakte tak med luftekanaler i isolasjonssjiktet og økt selvuttørkingsevne

Prosjektrapport 63 2010



SINTEF

Kompakte tak med luftekanaler og økt selvuttørkingsevne



Rain tightness around windows

SINTEF Byggforsk

ROBUST

HANS BOYE SKOGSTAD, TOR EVEN PEDERSEN OG ØYSTEIN HOLMBERGET

Regntetthet til vindsperre og tette-metoder rundt vindu

Laboratorieundersøkelse

Prosjektrapport 41 2009

SINTEF

Thicker insulation (passive houses) and moisture

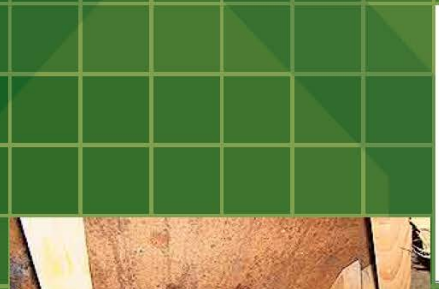
SINTEF Byggforsk

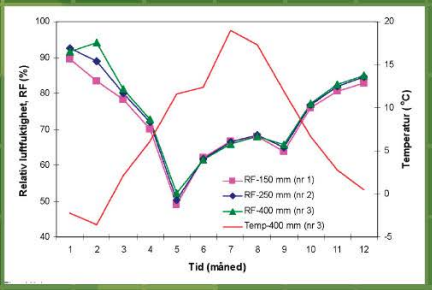
STIG GEVING OG JONAS HOLME

Høyisolerte konstruksjoner og fukt

Analyse av fuktttekniske konsekvenser av økt isolasjonstykkelse i yttervegger, tak, kryperom og kalde loft

Prosjektrapport 53 2010

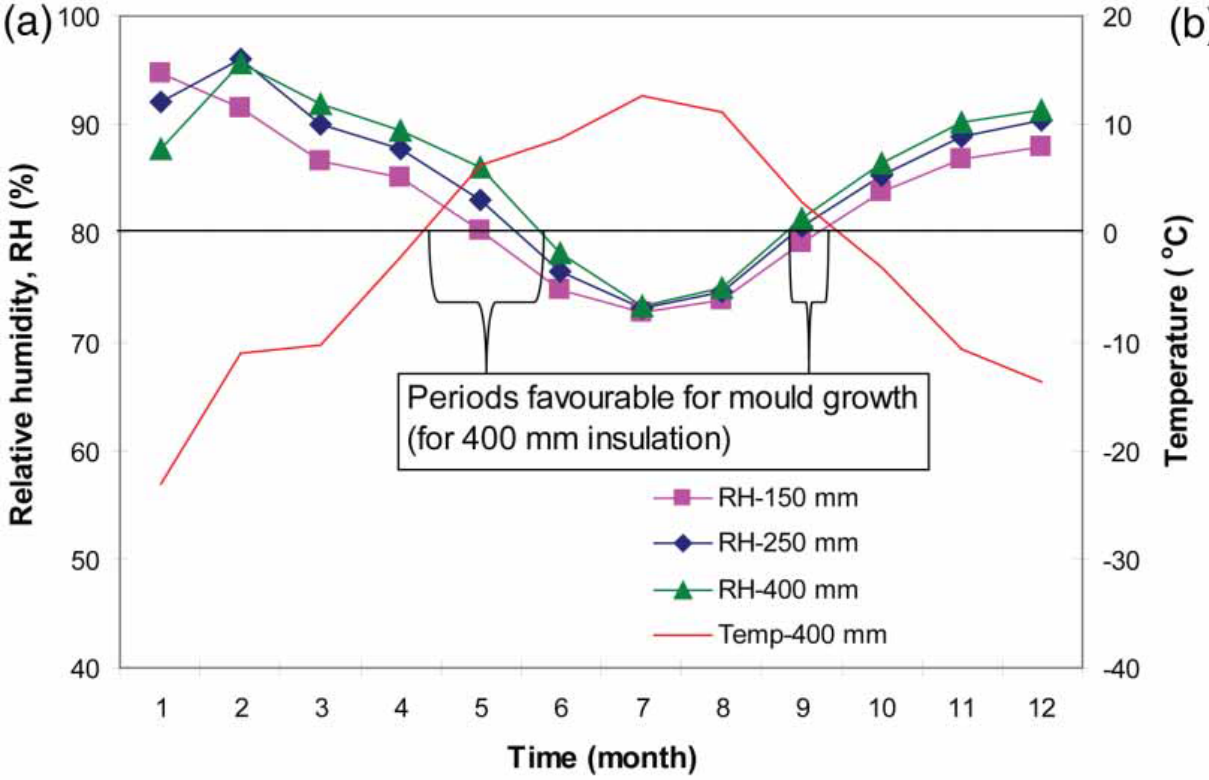




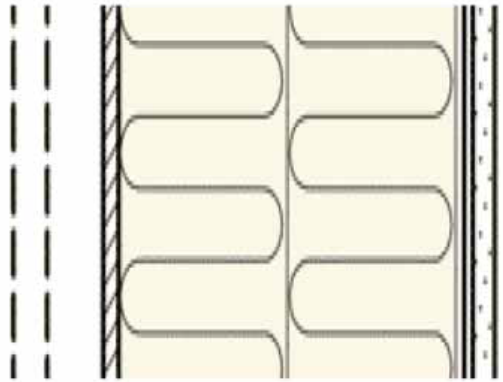
SINTEF

Results –Simulations Karasjok

(a)

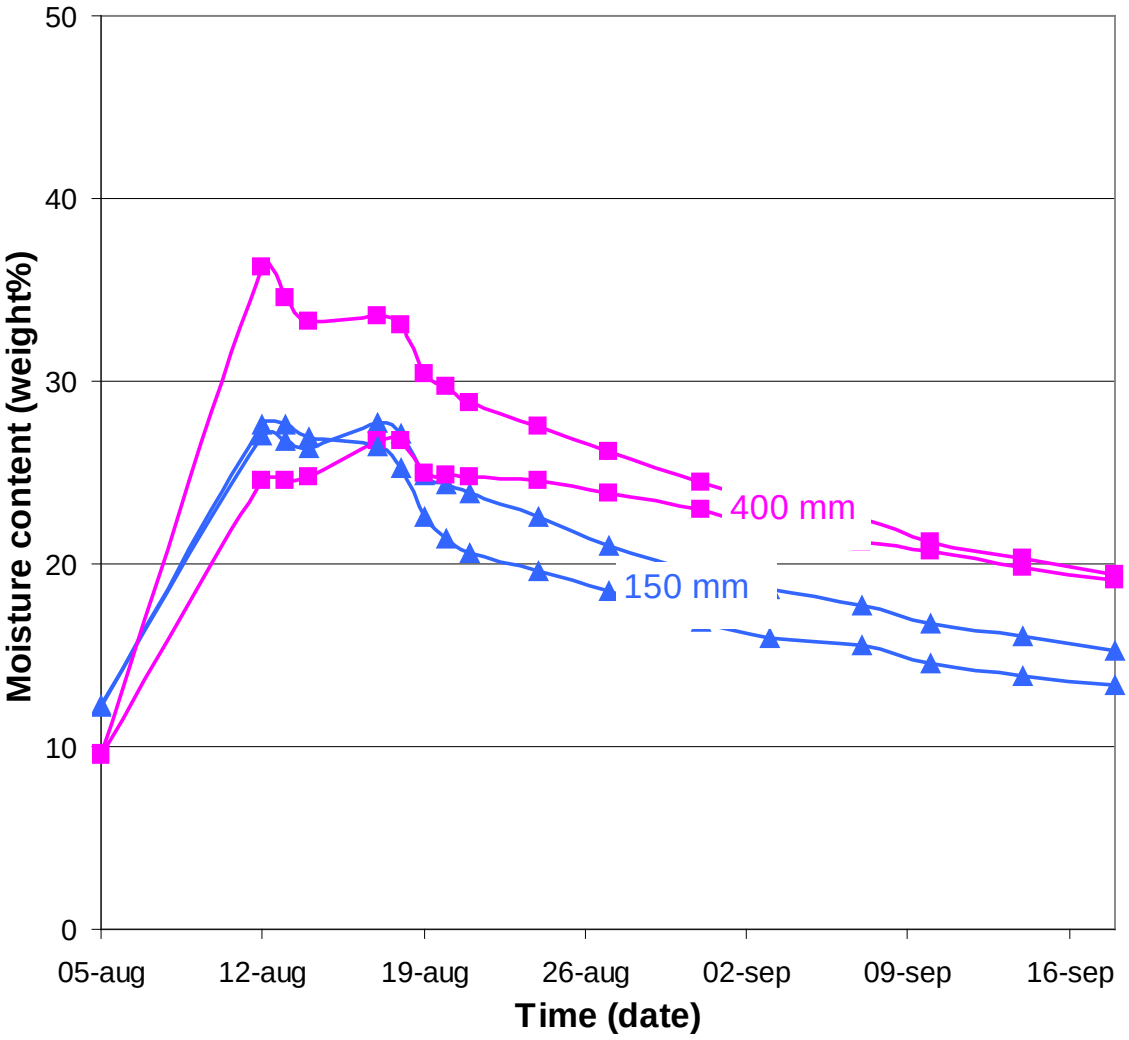


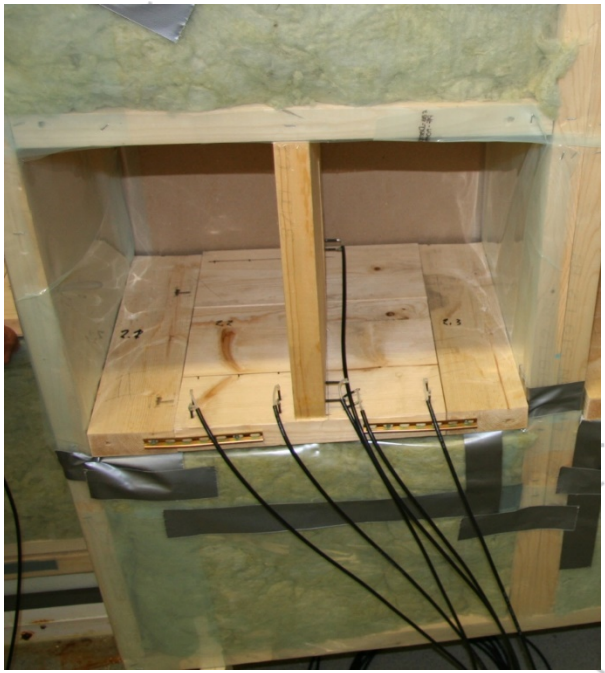
(b)



1. Ventilated wooden cladding
2. 12 mm wood fiber board (S_d =0,023 m)
3. 150-400 mm mineralwool
4. Vapour barrier (S_d = 10 m)
5. 12 mm gypsum board

Drying of high level of built-in-moisture (Wet bottom sill)



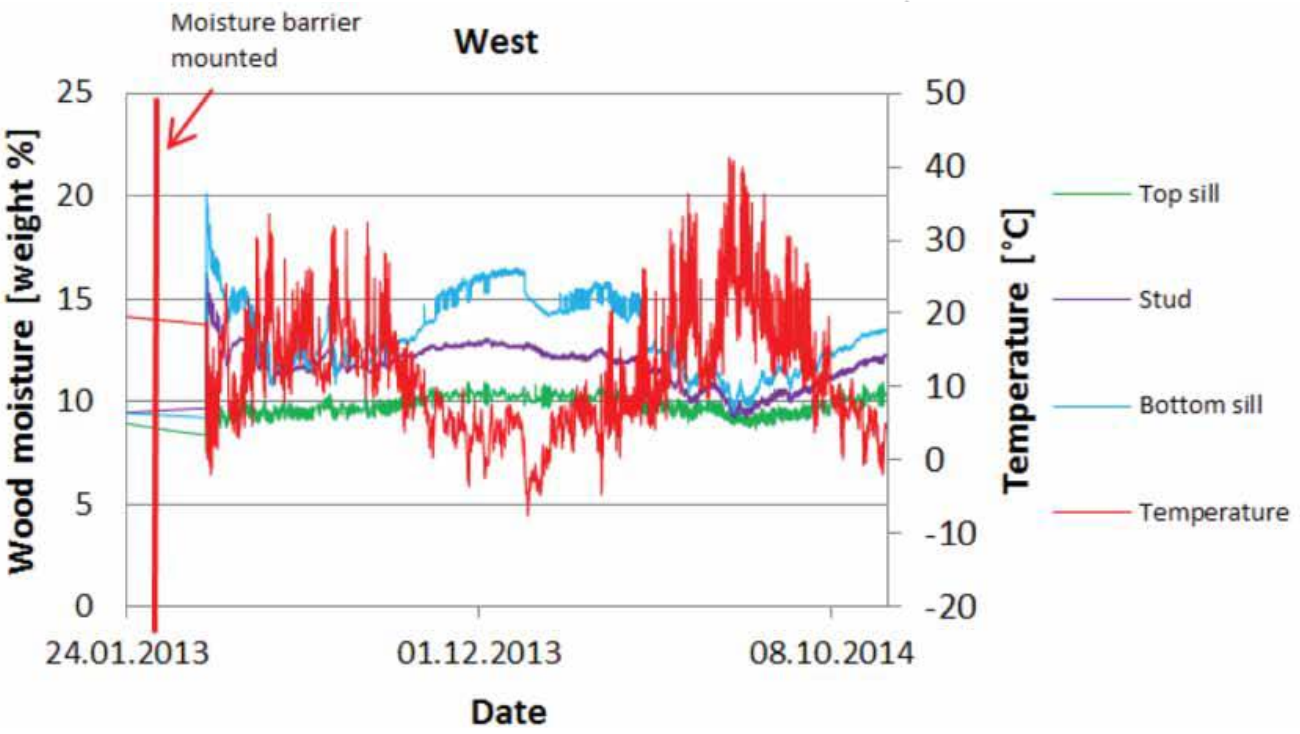


400 mm:

Approx. 2 x longer drying time to 20 weight%

Field measurements

Moisture content, 400 mm double timber frame wall



Alternative vapour barriers:

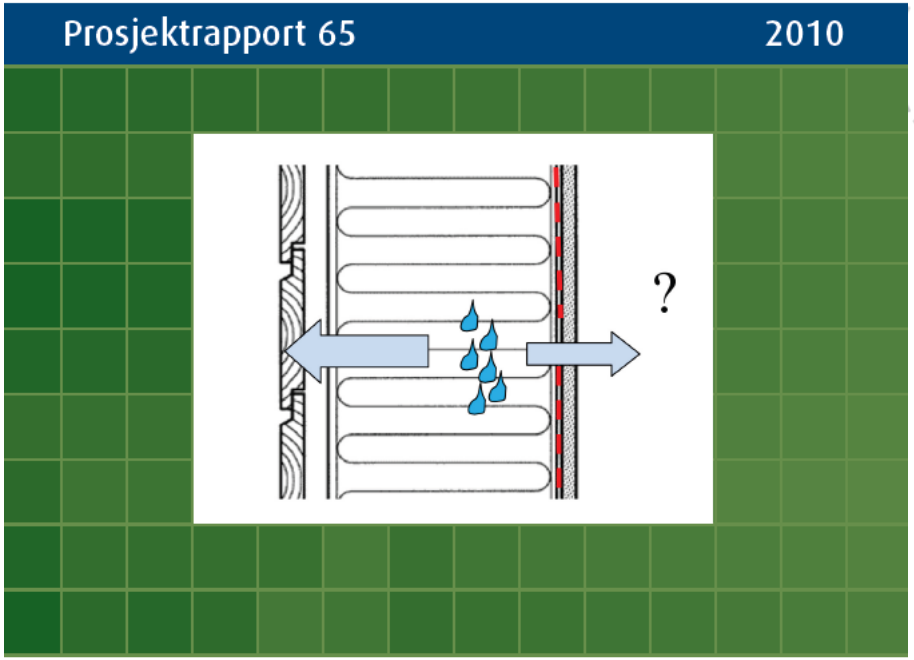
Vapour retarders vs. vapour barriers

SINTEF Byggforsk

STIG GEVING, JONAS HOLME OG SIVERT UVSLØKK

Alternative dampsperrer med uttørkingsmulighet mot innelufta

Prosjektrapport 65 2010



SINTEF

…continuing with

Smart vapour barriers

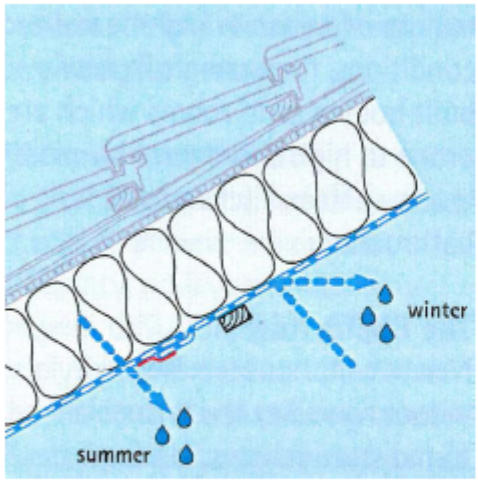


Figure: www.proclima.com

Smart vapour barriers in unventilated wooden roofs in a Nordic climate

– laboratory study of drying effect under shaded conditions

Stig Geving and Erik Thorsrud, *Norwegian University of Science and Technology (NTNU)*
Sivert Uvsløkk, *SINTEF, Norway*

Some PhDs from NTNU on MOISTURE

- Kim Robert Lisø (2006): **Building envelope performance assessment in harsh climates: Methods for geographically dependent design**
- Kristine Nore (2009): **Hygrothermal performance of ventilated wooden clading**
- Jonas Holme (2010): **Mould growth in buildings**
- Goce Talev (2011): **Convective moisture transfer coefficient for porous building material surfaces**
- Thor Oscar Relander (2011): **Airtightness of wood frame houses**
- **Jon Ivar Knarud (2013-2017): Moisture safe internal insulation of existing brick walls**
- Lars Gulbrekken (2014-2018): **Large ventilated wooden roofs**

NEW CENTER FOR RESEARCHDRIVEN INNOVATION (2015-2023)

SFI Klima 2050|Risk reduction through climate adaptation of buildings and infrastructure

Flere byer og tettsteder på Østlandet opplevde oversvømmelser og overvann etter et kraftig regnskyll søndag. Her fra Karl Johans gate i Oslo, som en stund minnet mer om en innsjø enn en travel turist- og handlegate. Avløpene greide ikke å ta unna i samme takt som vannet fosset ned. FOTO: NTB SCANPIX

Styrtregn i byene koster langt mer enn flom

Voldsomme regnbyger på Østlandet skapte oversvømmelser i flere byer og tettsteder søndag.

Adresseavisen 02.06.2013

Goals

Klima 2050 will reduce the societal risks associated with climate changes and enhanced precipitation and flood water exposure within the built environment.

Emphasis will be placed on development of

- WP1: moisture-resilient buildings,
- WP2: stormwater management,
- WP3: measures for prevention of water-triggered landslides,
- WP4: socio-economic incentives and decision-making processes.

Both extreme weather and gradual changes in the climate will be addressed.

Photos: Internett

WP1: Climate exposure and moisture-resilient buildings

Develop principles, methods and solutions for a future climate-robust sustainable building stock, considering both existing and new buildings.

Green roofs important research topic

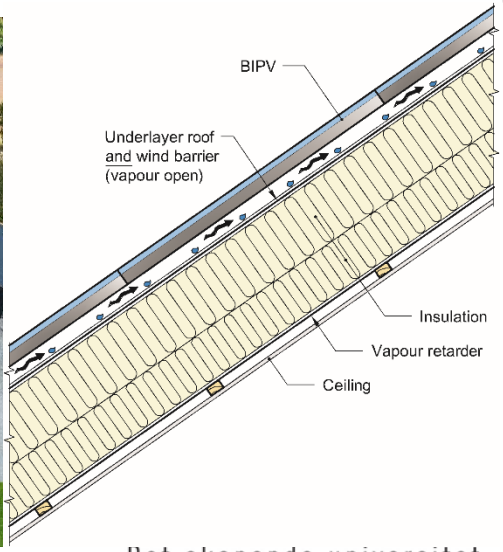
Example of project:

Large ventilated wooden roofs

Increased interest in LARGE, LOW SLOPE wooden roofs

Increased insulation thickness

How do we ventilate these roofs and avoid snow melting and condensation?




THANKS FOR THE
ATTENTION!!