ROBUST

Robust Envelope Construction Details for Buildings of the 21st Century

av Vivian Meløysund, SINTEF Byggforsk

Norsk bygningsfysikkdag 2011

29. november 2011

ROBUST (2008 – 2012)

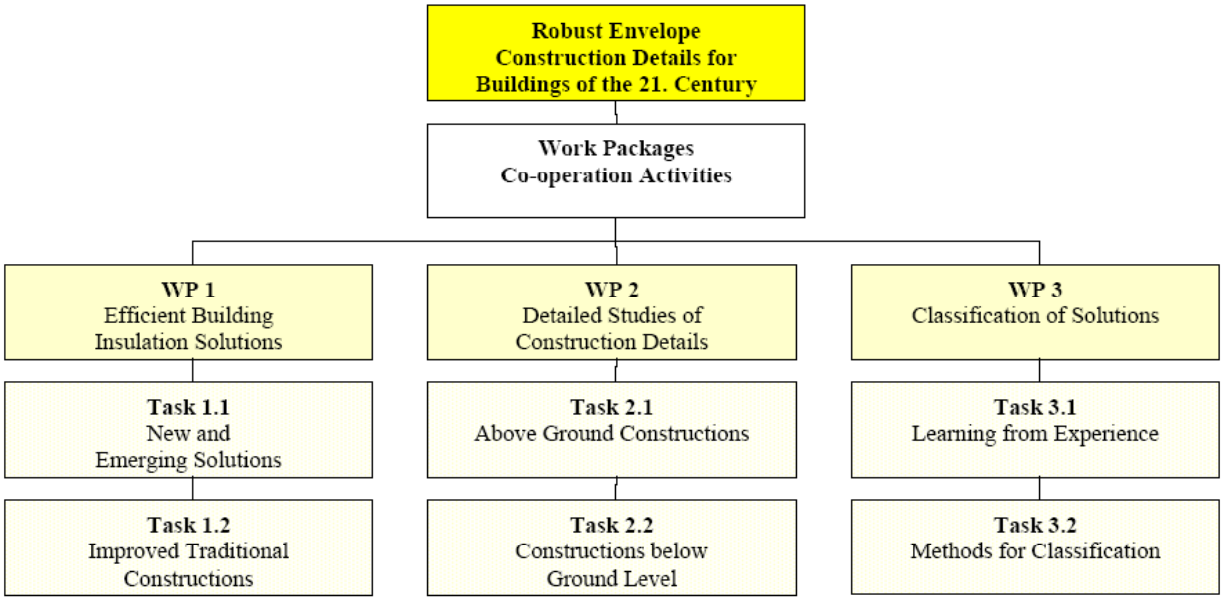
- FoU-prosjekt støttet av Norges Forskningsråd
- Budsjett på 18 mill. NOK
- Samarbeid med NTNU og 12 partnere fra byggenæringen

Foto: Scanpix/Reuters

- Hovedmål:

  Utvikle klimatilpassede, miljø- og energieffektive konstruksjonsløsninger for dagens og fremtidens bygninger

Prosjektet



Samarbeidspartnere i prosjektet

BAE-næringen

- AF-gruppen
- Glava
- Hunton Fiber as
- Icopal
- Isola
- Jackon
- Maxit
- Moelven ByggModul
- Rambøll
- Skanska
- Statsbygg
- Takprodusentenes forskningsgruppe (TPF)

Andre

- SINTEF Byggforsk
- NTNU

ROBUST (2008 – 2012)

Vakuumisolasjonspaneler har
1/5 – 1/10 lavere varmeledningsevne
enn mineralull

WP 1 Effektive isolasjonsmaterialer

- Highly thermal insulation solutions
- Low-emissivity coating
- Electrocromic windows
- Vacuum Insulation Panels
- Solar Glazing Factors
- Convection in thick insulation layers

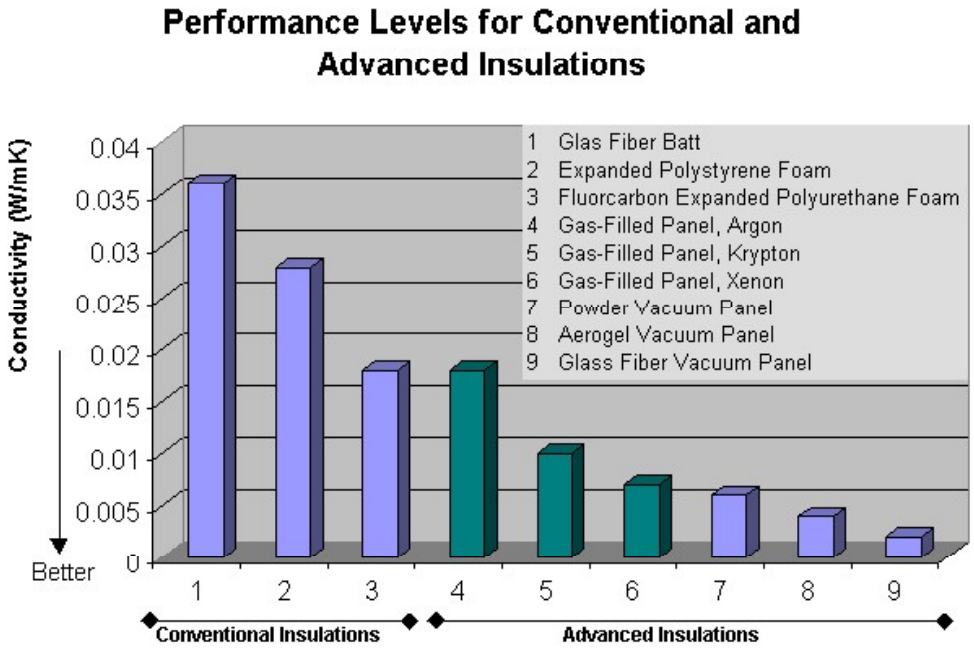
WP 2 Robuste konstruksjonsløsninger

- Utvikling av fuktsikre, skrå tretak
- God luft- og damptetthet
- Fuktsikre, høyisolerte yttervegger
- Lufting av kalde loft
- Kompakte, flate tak
- Isolerte yttervegger mot terreng
- Frostisolering av gulvkonstruksjoner

WP 3 Klassifisering av løsninger

- Utvikling av metoder for klassifisering
- Mikrobiologisk vekst på fasade
- Fuktskader og muggvekst
- Regntetthet i vindsperresjiktet
- Geografisk differensiert prosjektering

Fremtidens varmeisolasjonsmaterialer



http://gfp.lbl.gov/performance

Energy and Buildings 42 (2010) 147–172

Contents lists available at ScienceDirect

Energy and Buildings

journal homepage: www.elsevier.com/locate/enbuild

Review

Vacuum insulation panels for building applications: A review and beyond

Ruben Baetens [a,b,c], Bjørn Petter Jelle [a,b,*], Jan Vincent Thue [b], Martin J. Tenpierik [d], Steinar Grynning [a], Sivert Uvsløkk [a], Arild Gustavsen [e]

[a] Department of Building Materials and Structures, SINTEF Building and Infrastructure, NO-7465 Trondheim, Norway
[b] Department of Civil and Transport Engineering, Norwegian University of Science and Technology (NTNU), NO-7491 Trondheim, Norway
[c] Laboratory of Building Physics, Department of Civil Engineering, Catholic University of Leuven (KUL), BE-3001 Heverlee, Belgium
[d] Faculty of Architecture, Urbanism and Building Sciences, Delft University of Technology, Julianalaan 134, 2628 BL Delft, The Netherlands
[e] Department of Architectural Design, History and Technology, Norwegian University of Science and Technology (NTNU), NO-7491 Trondheim, Norway

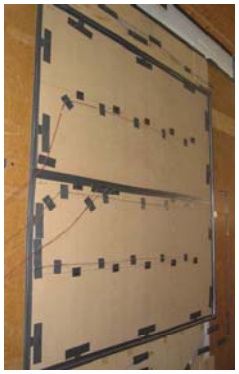
ARTICLE INFO

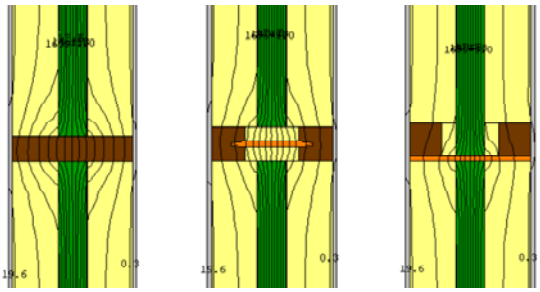
Article history:
Received 22 December 2008
Received in revised form 3 September 2009
Accepted 14 September 2009

Keywords:
Vacuum insulation panel (VIP)
Building insulation

ABSTRACT

Vacuum insulation panels (VIPs) are regarded as one of the most promising high performance thermal insulation solutions on the market today. Thermal performances three to six times better than still-air are achieved by applying a vacuum to an encapsulated micro-porous material, resulting in a great potential for combining the reduction of energy consumption in buildings with slim constructions. However, thermal bridging due to the panel envelope and degradation of thermal performance through time occurs with current technology. Furthermore, VIPs cannot be cut on site and the panels are fragile towards damaging. These effects have to be taken into account for building applications as they may diminish the overall usability and thermal performance.





Energy and Buildings 42 (2010) 1969–1975

Contents lists available at ScienceDirect

Energy and Buildings

journal homepage: www.elsevier.com/locate/enbuild

Review

Gas-filled panels for building applications: A state-of-the-art review

Ruben Baetens [a,b,c], Bjørn Petter Jelle [a,c,*], Arild Gustavsen [d], Steinar Grynning [a]

[a] Department of Materials and Structures, SINTEF Building and Infrastructure, NO-7465 Trondheim, Norway
[b] Department of Civil Engineering, K.U. Leuven, B-3001 Heverlee, Belgium
[c] Department of Civil and Transport Engineering, Norwegian University of Science and Technology (NTNU), NO-7491 Trondheim, Norway
[d] Department of Architectural Design, History and Technology, Norwegian University of Science and Technology (NTNU), NO-7491 Trondheim, Norway

ARTICLE INFO

Article history:
Received 15 October 2009
Received in revised form 9 June 2010
Accepted 27 June 2010

Keywords:
Gas-filled panel
GFP
High performance thermal insulation material

ABSTRACT

With their thermal conductivity down to 10
high performance thermal insulating solution
of respectively 46 and 40 mW/m K have so
panels, values slightly higher than currently
high performance thermal insulation materi
future of GFPs may therefore be questioned.
reflective barriers may have a potential in the
materials. Within this work, a state-of-the-
applications today.

Foto: Aspen Aerogels Inc.

Energy and Buildings 43 (2011) 761–769

Contents lists available at ScienceDirect

Energy and Buildings

journal homepage: www.elsevier.com/locate/enbuild

Review

Aerogel insulation for building applications: A state-of-the-art review

Ruben Baetens [a,b,c], Bjørn Petter Jelle [a,c,*], Arild Gustavsen [d]

[a] Department of Materials and Structures, SINTEF Building and Infrastructure, Høgskoleringen 7B, NO-7465 Trondheim, Norway
[b] Division of Building Physics, Department of Civil Engineering, K.U. Leuven, BE-3001 Heverlee, Belgium
[c] Department of Civil and Transport Engineering, Norwegian University of Science and Technology (NTNU), NO-7491 Trondheim, Norway
[d] Department of Architectural Design, History and Technology, Norwegian University of Science and Technology (NTNU), NO-7491 Trondheim, Norway

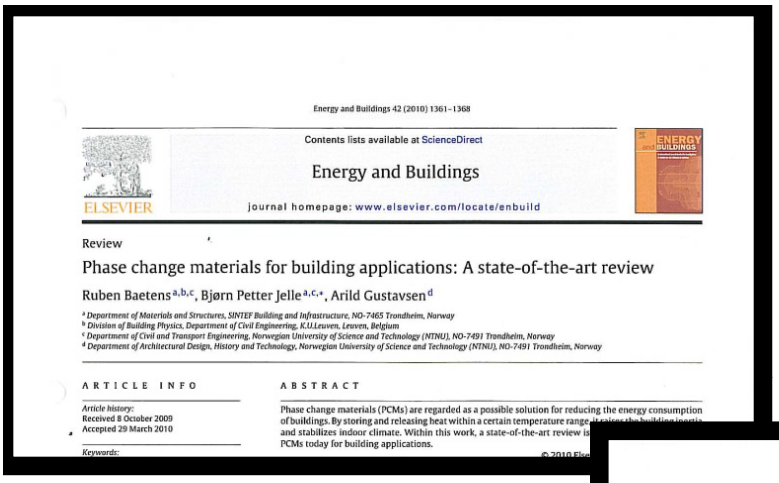
ARTICLE INFO

Article history:
Received 5 October 2010
Received in revised form 2 November 2010
Accepted 8 December 2010

Keywords:
Aerogel

ABSTRACT

Aerogels are regarded as one of the most promising high performance thermal insulation materials for building applications today. With a thermal conductivity down to 13 mW/(m K) for commercial products they show remarkable characteristics compared to traditional thermal insulation materials. Also the possibility of high transmittances in the solar spectrum is of high interest for the construction sector. With the proper knowledge they give both the architect and engineer the opportunity of re-inventing architectural solutions. Within this work, a review is given on the knowledge of aerogel insulation in general and for building applications in particular.



Energy and Buildings 42 (2010) 1361–1368

Contents lists available at ScienceDirect

Energy and Buildings

journal homepage: www.elsevier.com/locate/enbuild

Review

Phase change materials for building applications: A state-of-the-art review

Ruben Baetens [a,b,c], Bjørn Petter Jelle [a,c,*], Arild Gustavsen [d]

[a] Department of Materials and Structures, SINTEF Building and Infrastructure, NO-7465 Trondheim, Norway
[b] Division of Building Physics, Department of Civil Engineering, K.U.Leuven, Leuven, Belgium
[c] Department of Civil and Transport Engineering, Norwegian University of Science and Technology (NTNU), NO-7491 Trondheim, Norway
[d] Department of Architectural Design, History and Technology, Norwegian University of Science and Technology (NTNU), NO-7491 Trondheim, Norway

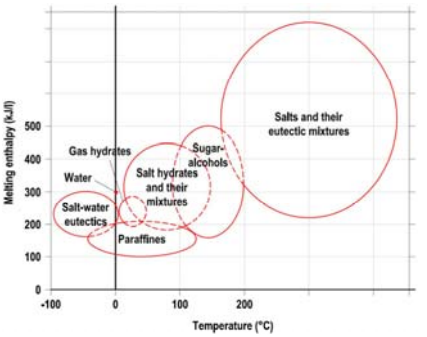
ARTICLE INFO

Article history:
Received 8 October 2009
Accepted 29 March 2010

Keywords:

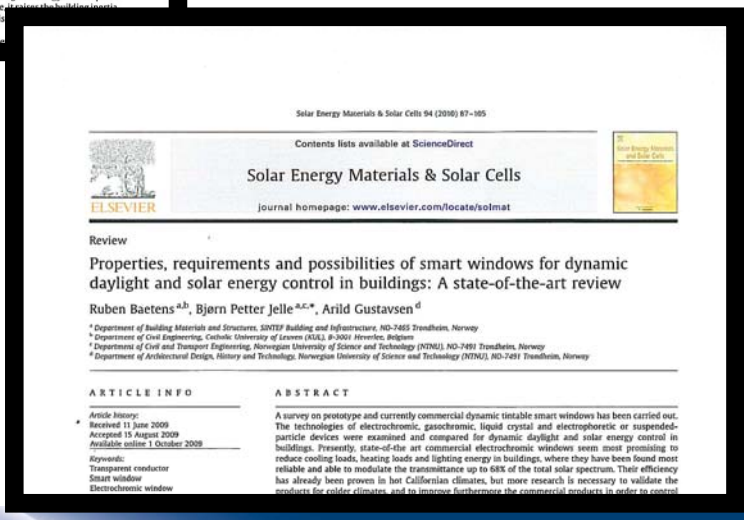
ABSTRACT

Phase change materials (PCMs) are regarded as a possible solution for reducing the energy consumption of buildings. By storing and releasing heat within a certain temperature range it raises the building inertia and stabilizes indoor climate. Within this work, a state-of-the-art review is PCMs today for building applications.



www.eurosolar.org

www.gesimat.de



Solar Energy Materials & Solar Cells 94 (2010) 87–105

Contents lists available at ScienceDirect

Solar Energy Materials & Solar Cells

journal homepage: www.elsevier.com/locate/solmat

Review

Properties, requirements and possibilities of smart windows for dynamic daylight and solar energy control in buildings: A state-of-the-art review

Ruben Baetens [a,b], Bjørn Petter Jelle [a,c,*], Arild Gustavsen [d]

[a] Department of Building Materials and Structures, SINTEF Building and Infrastructure, NO-7465 Trondheim, Norway
[b] Department of Civil Engineering, Catholic University of Leuven (KUL), B-3001 Heverlee, Belgium
[c] Department of Civil and Transport Engineering, Norwegian University of Science and Technology (NTNU), NO-7491 Trondheim, Norway
[d] Department of Architectural Design, History and Technology, Norwegian University of Science and Technology (NTNU), NO-7491 Trondheim, Norway

ARTICLE INFO

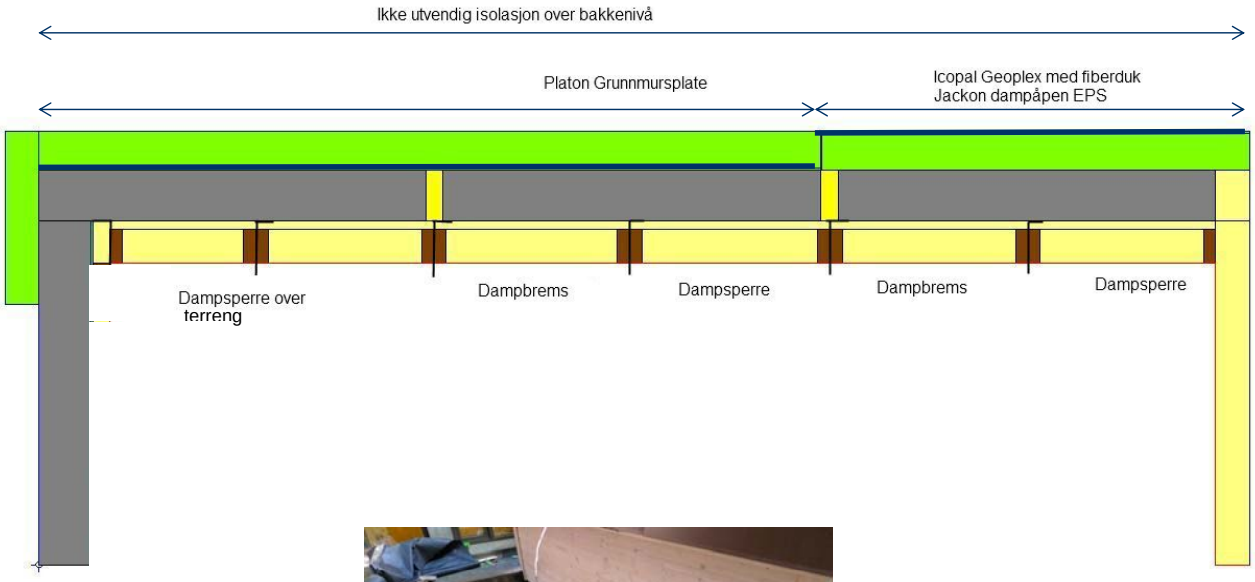
Article history:
Received 11 June 2009
Accepted 15 August 2009
Available online 1 October 2009

Keywords:
Transparent conductor
Smart window
Electrochromic window

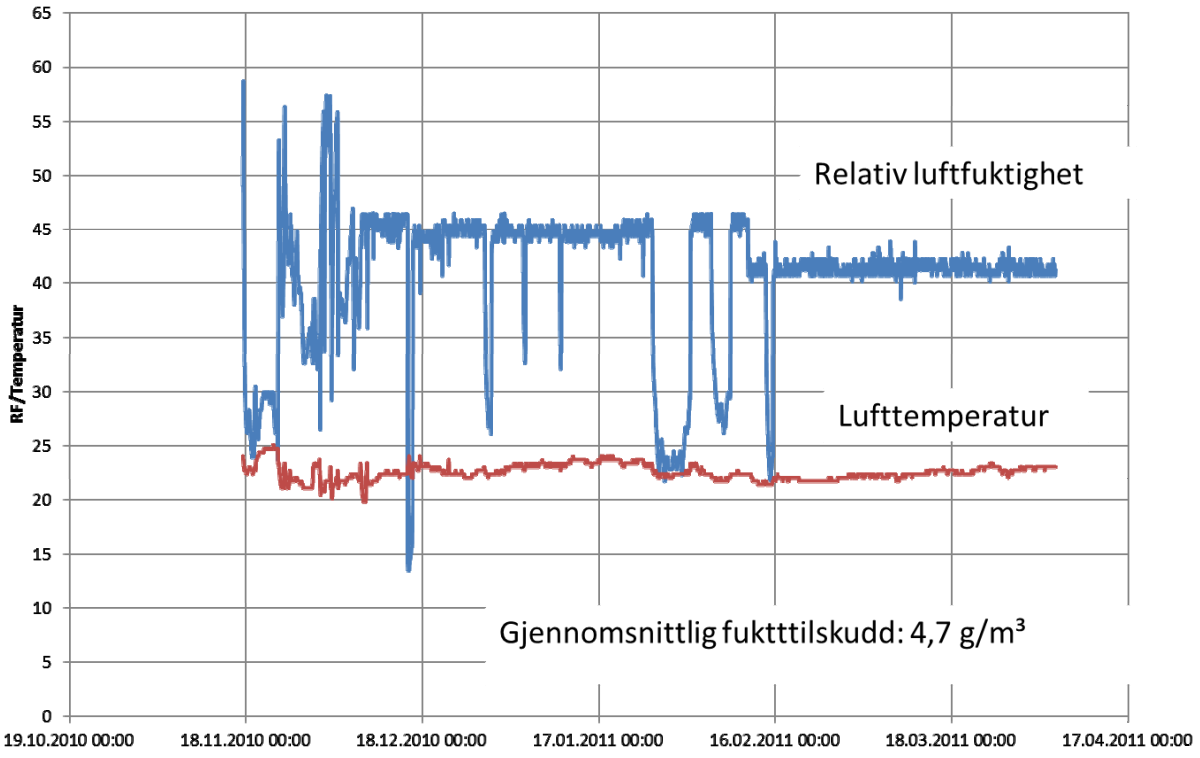
ABSTRACT

A survey on prototype and currently commercial dynamic tintable smart windows has been carried out. The technologies of electrochromic, gasochromic, liquid crystal and electrophoretic or suspended-particle devices were examined and compared for dynamic daylight and solar energy control in buildings. Presently, state-of-the art commercial electrochromic windows seem most promising to reduce cooling loads, heating loads and lighting energy in buildings, where they have been found most reliable and able to modulate the transmittance up to 68% of the total solar spectrum. Their efficiency has already been proven in hot Californian climates, but more research is necessary to validate the products for colder climates, and to improve furthermore the commercial products in order to control

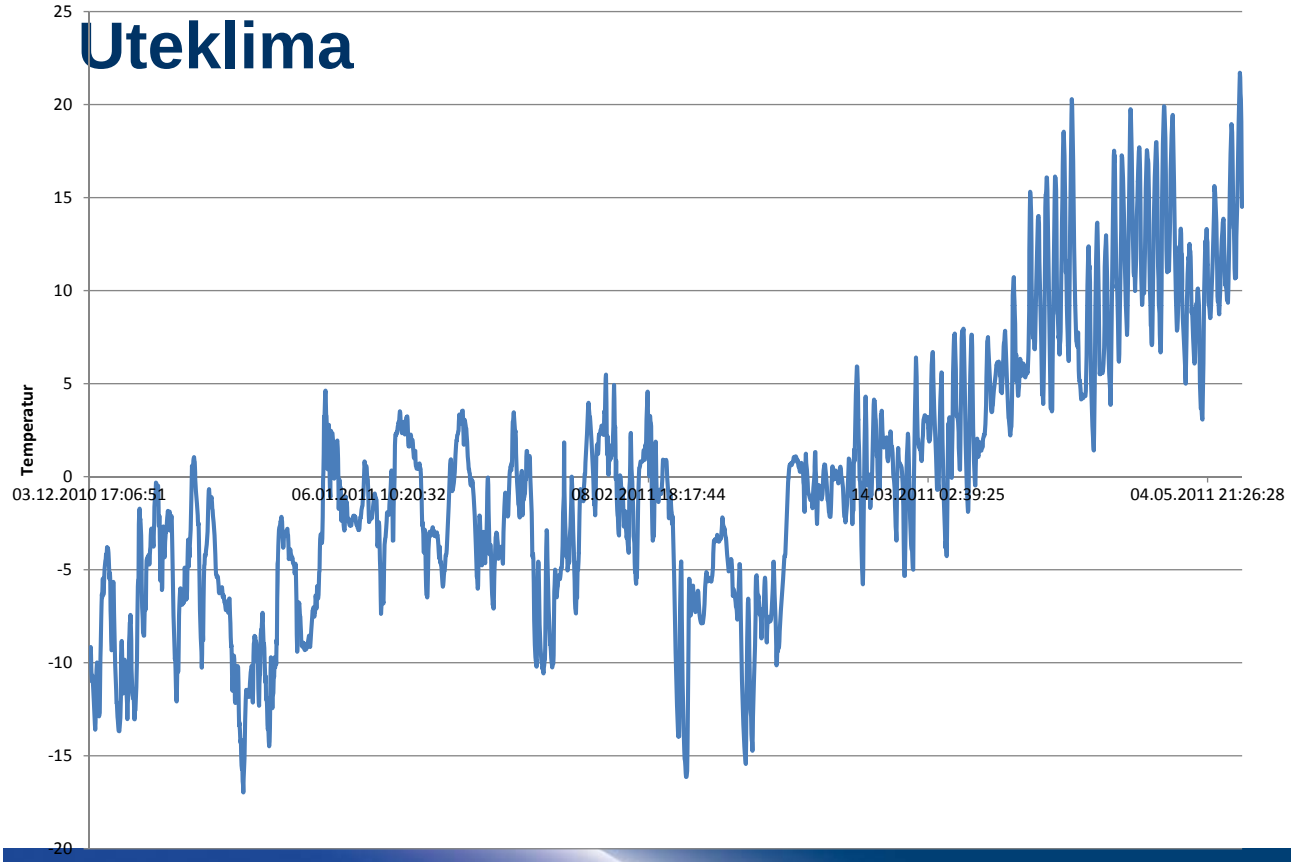
Kjellerytterveggger mot terreng


Ikke utvendig isolasjon over bakkenivå
Platon Grunnmursplate
Icopal Geoplex med fiberduk
Jackon dampåpen EPS
Dampsperre over terreng
Dampbrems
Dampsperre
Dampbrems
Dampsperre

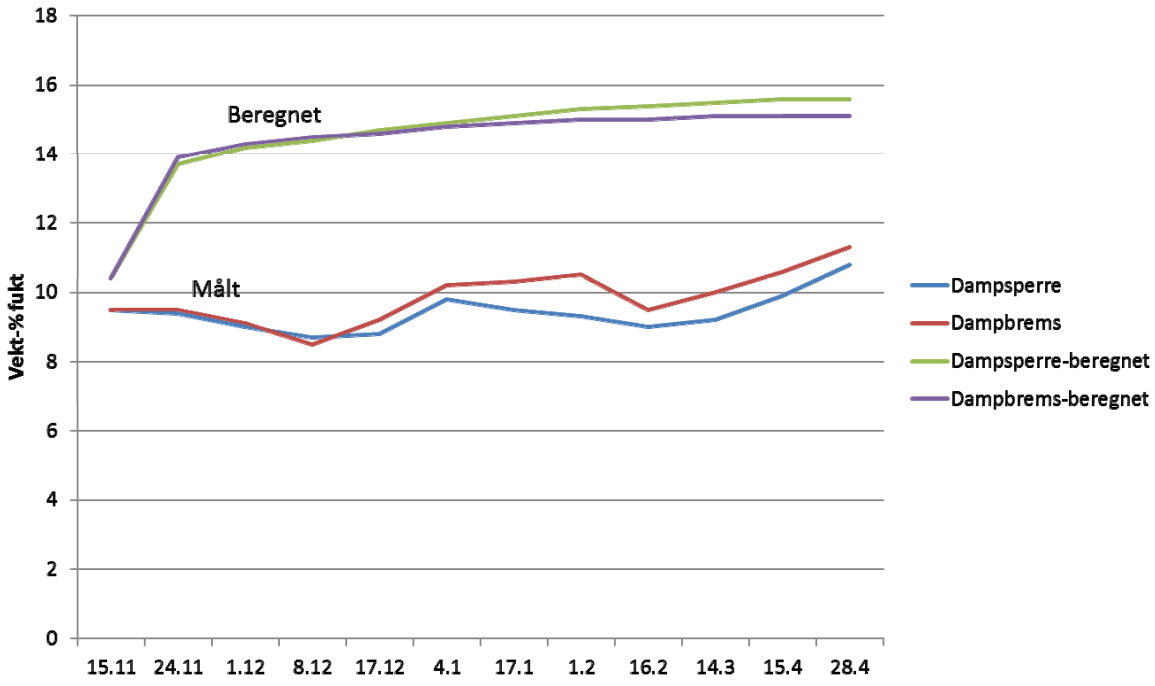
Romklima


RF/Temperatur
65
60
55
50
45
40
35
30
25
20
15
10
5
0
19.10.2010 00:00
18.11.2010 00:00
18.12.2010 00:00
17.01.2011 00:00
16.02.2011 00:00
18.03.2011 00:00
17.04.2011 00:00
Relativ luftfuktighet
Lufttemperatur
Gjennomsnittlig fuktttilskudd: 4,7 g/m³

Uteklima

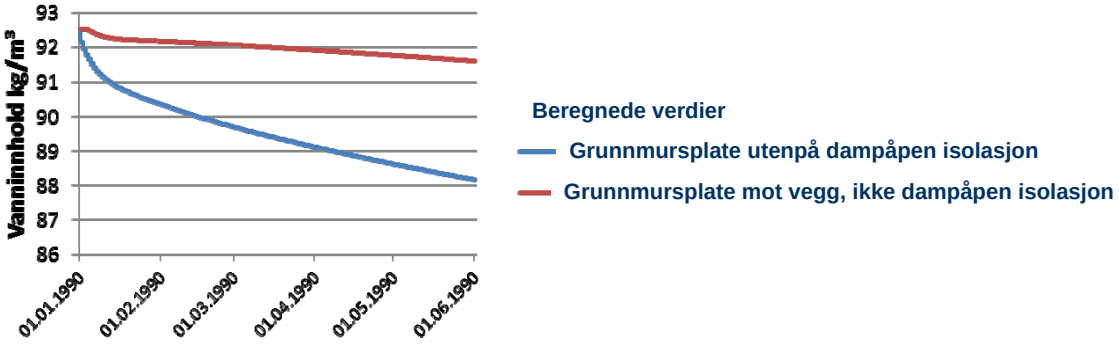


Fuktinnhold innvendig stender under terreng

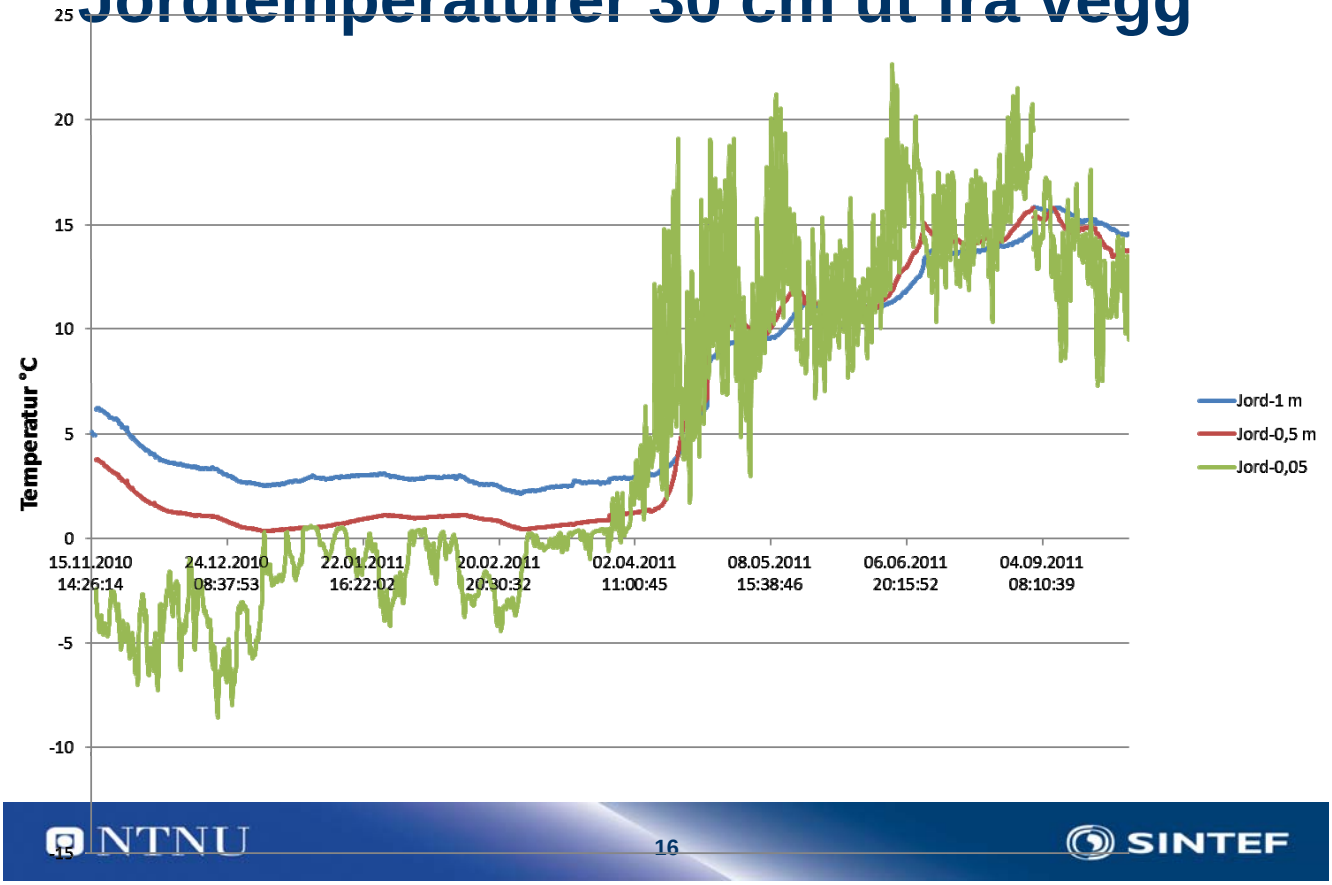


Fuktinnhold betong

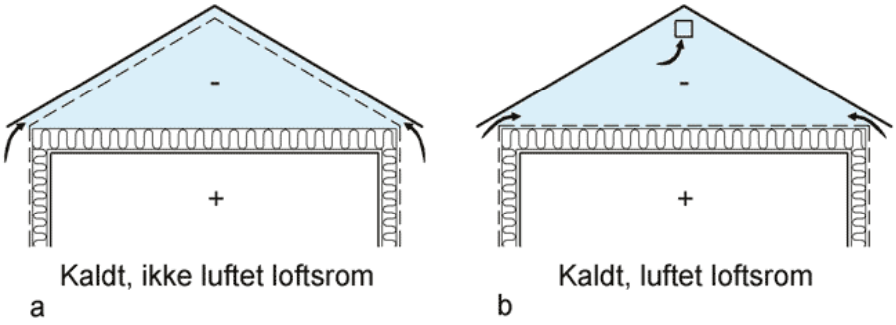
- Foreløpige resultater tyder på lavere fuktighet i betongen i felt med dampåpen isolasjon og grunnmursplate på utsiden av isolasjonen.
- Gevinsten ved tørrere betong må vurderes opp mot andre hensyn: Knasteplate festet direkte mot kjellervegg gir en ekstra gir sikkerhet mot vanninntrengning utenfra.

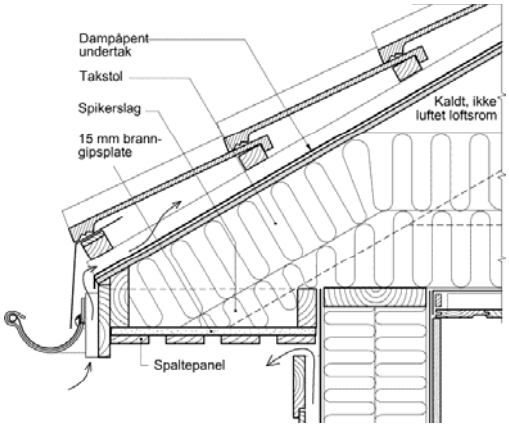


Jordtemperaturer 30 cm ut fra vegg



Uluftede kalde loft

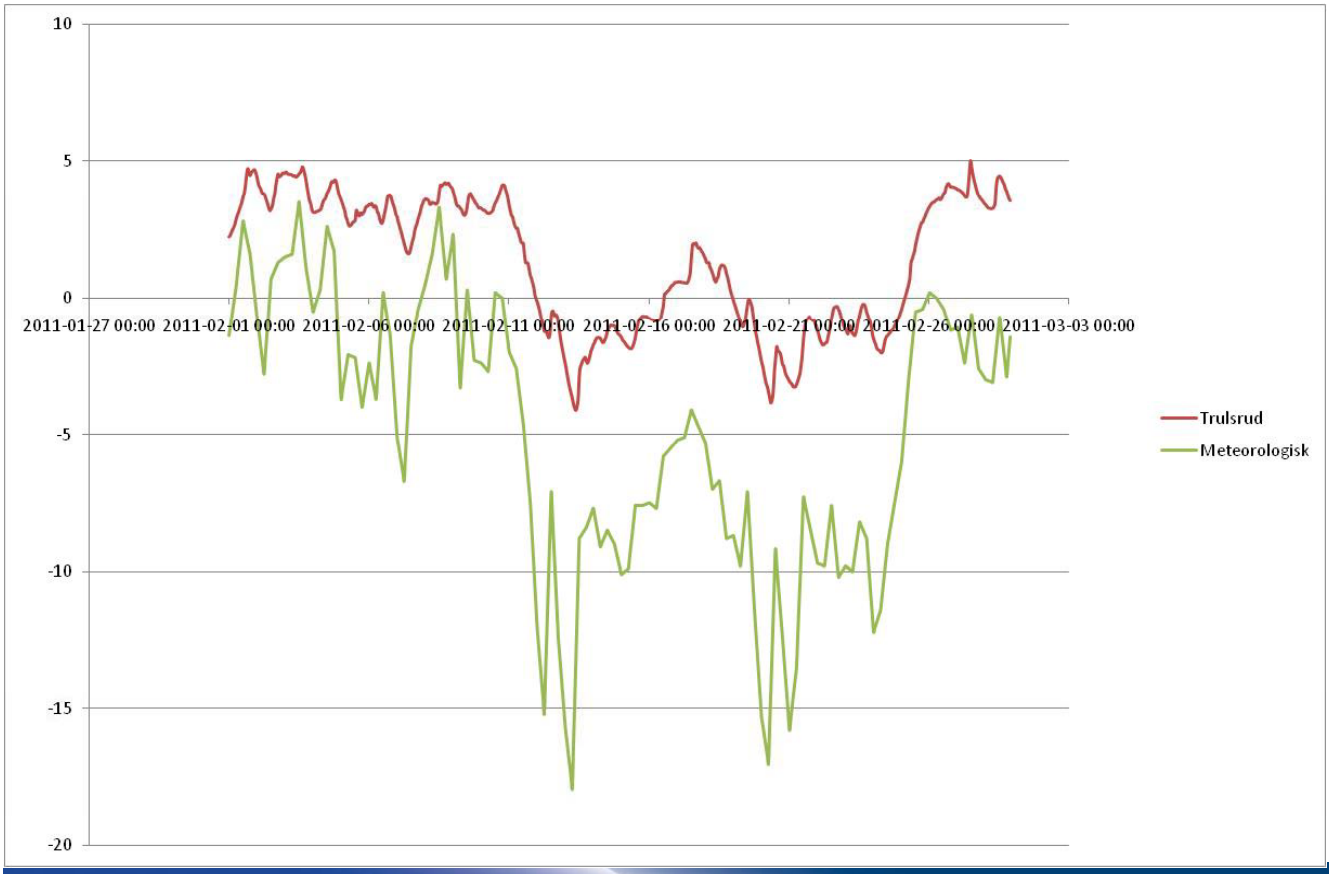




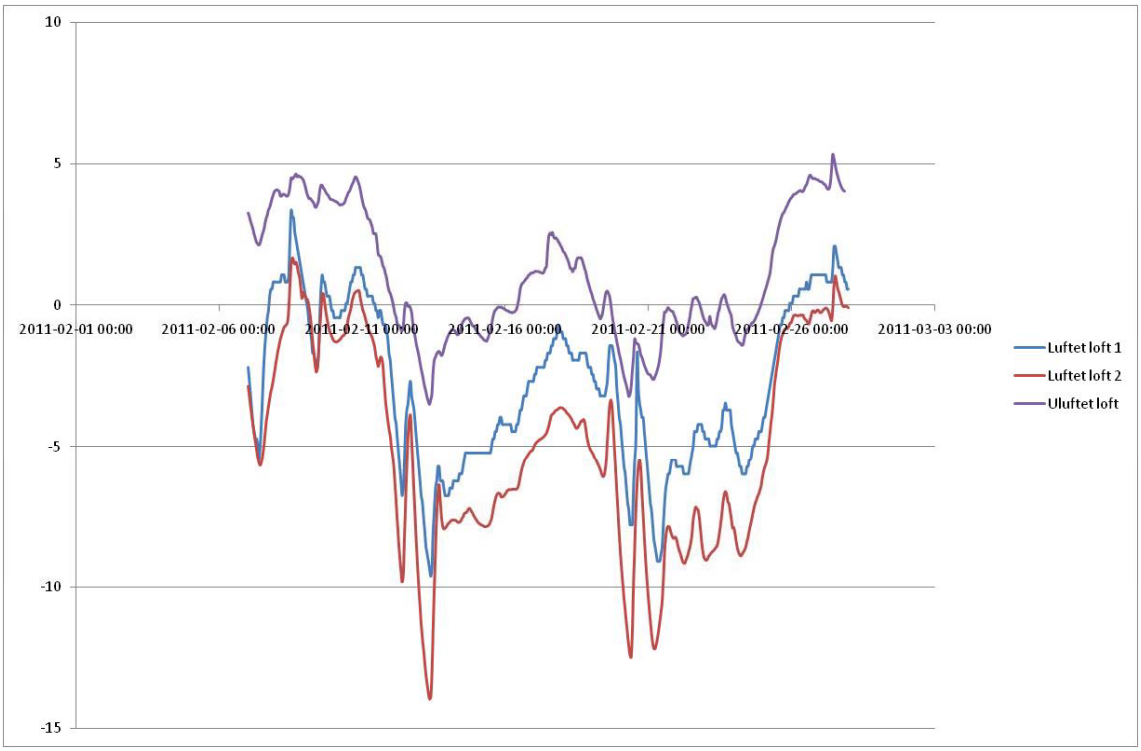
Fordeler med uluftede loft
- forhindre brannspredning
- hindre snøinndrev

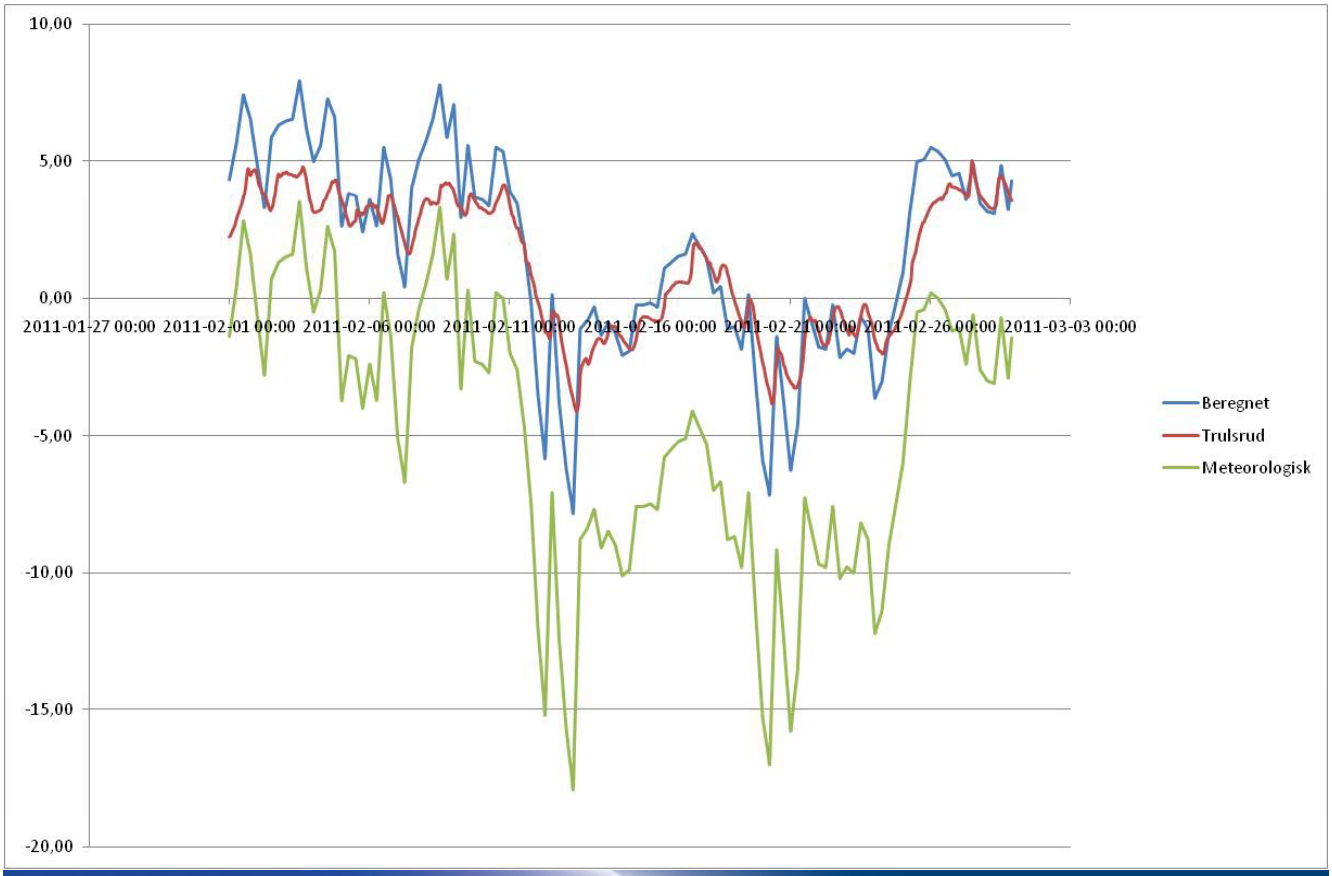
Dampåpent undertak for uttørking av byggfukt

Uluftede kalde loft



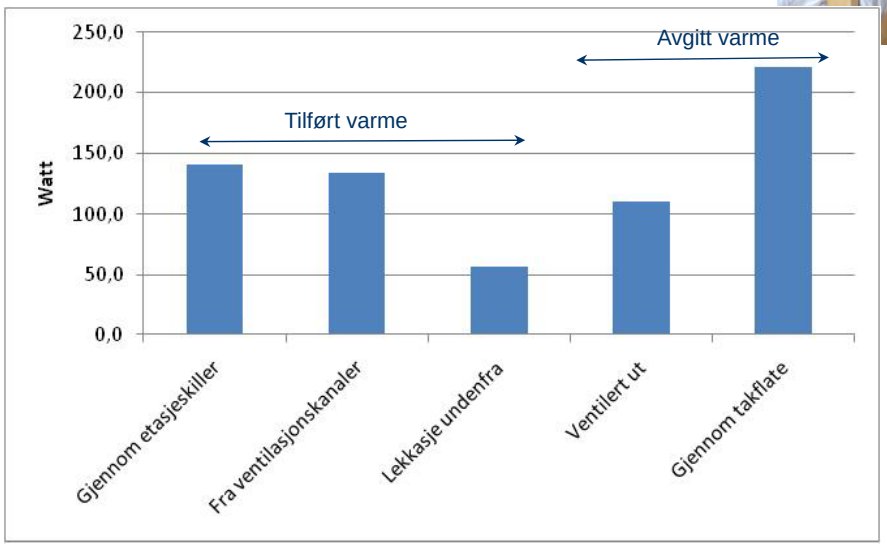
Lufting av kalde loft





Varmebalanse loft

-7 grader
30 cm snø
Tett hus



Resultater fra feltundersøkelse

- 6 uluftede kalde loft med kondensproblemer

Building	Cause of damage
1	*High built-in moisture, secondary also air leakages from the ground through wall between flats*
2	*High built-in moisture, secondary also air leakages from the ground through wall between flats*
3	*High built-in moisture*
4	*Primary high built-in moisture, secondary also air leakages*
5	High built-in moisture
6	Combination of high built-in moisture and air leakages through trapdoor and ventilation tube

Tiltak mot kondens

- lavt fuktinnhold i treverket før isolering (mindre enn ca. 15 vekt-%)
- skjerme treverket mot nedbør i byggeperioden
- bruke sperrer med lite byggfukt (I-profiler, gitterdragere, K-bjelker)
- tørke treverket ved å ventilere med noe oppvarming i noen uker før isolering og lukking. Alternativ kan det benyttes luftavfuktere

- legge på dampsperre raskt etter at isoleringsarbeidet er fullført
- montere dampsperre med tette skjøter

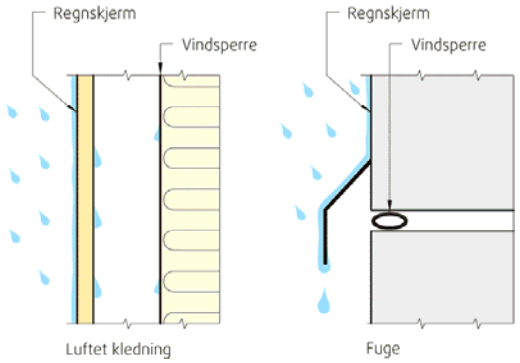
- lav dampmotstand i vindsperre/undertak (< 0,1 m ekvivalent luftlagstykkelse, s_d)
- vindsperre/undertak med en viss kondensopptaksevne

Kompakte tak

www.sintefbok.no

Prøving av regntetthet til vindsperre og tettemetoder rundt vindu

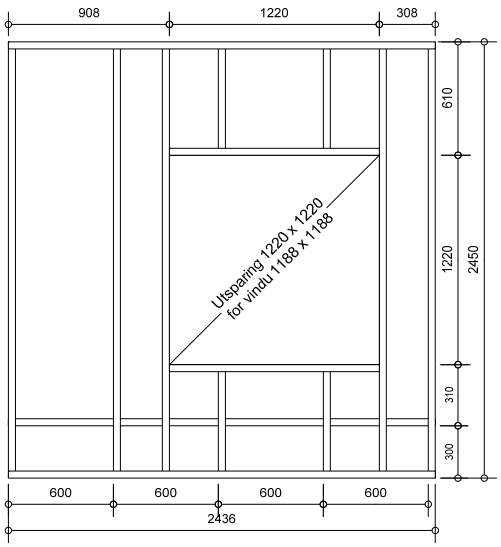
- Mer vær – regn og vind
- Regntetthet i byggeperioden før kledning
- Nye kledningssystemer slipper mer slagregn inn på vindsperre



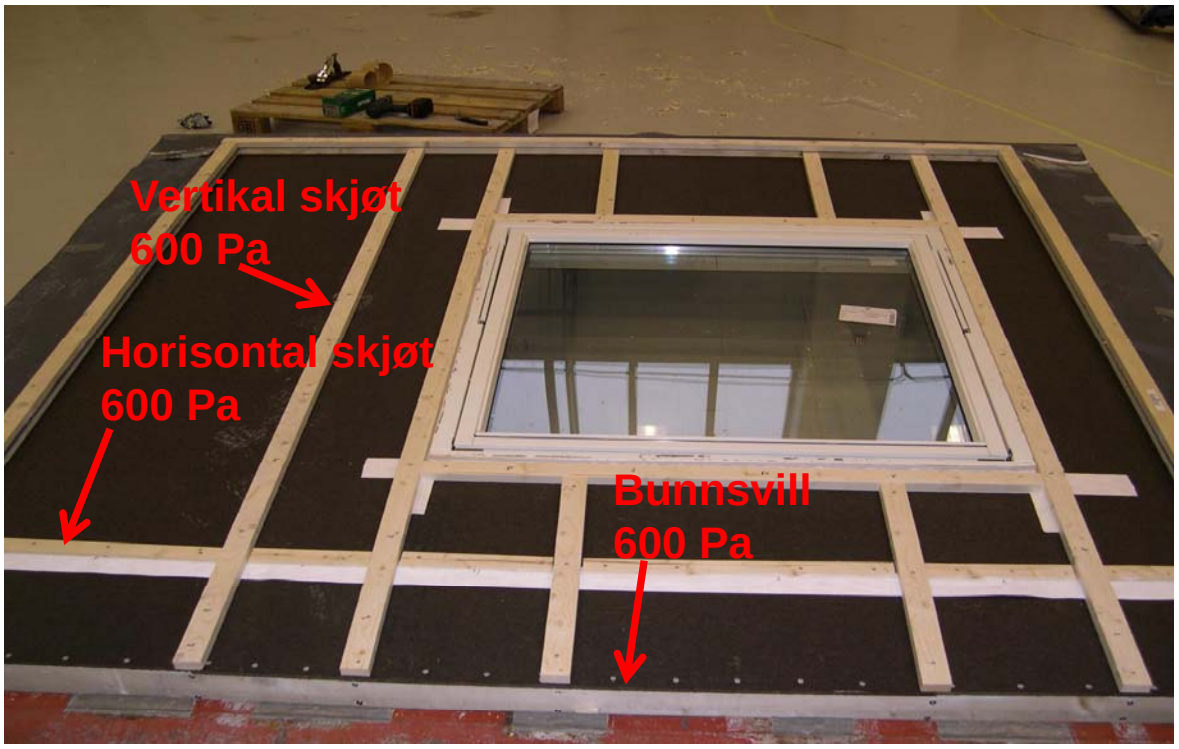
Prøving av regntetthet

NS-EN 1027: metode 1A - statisk trykk

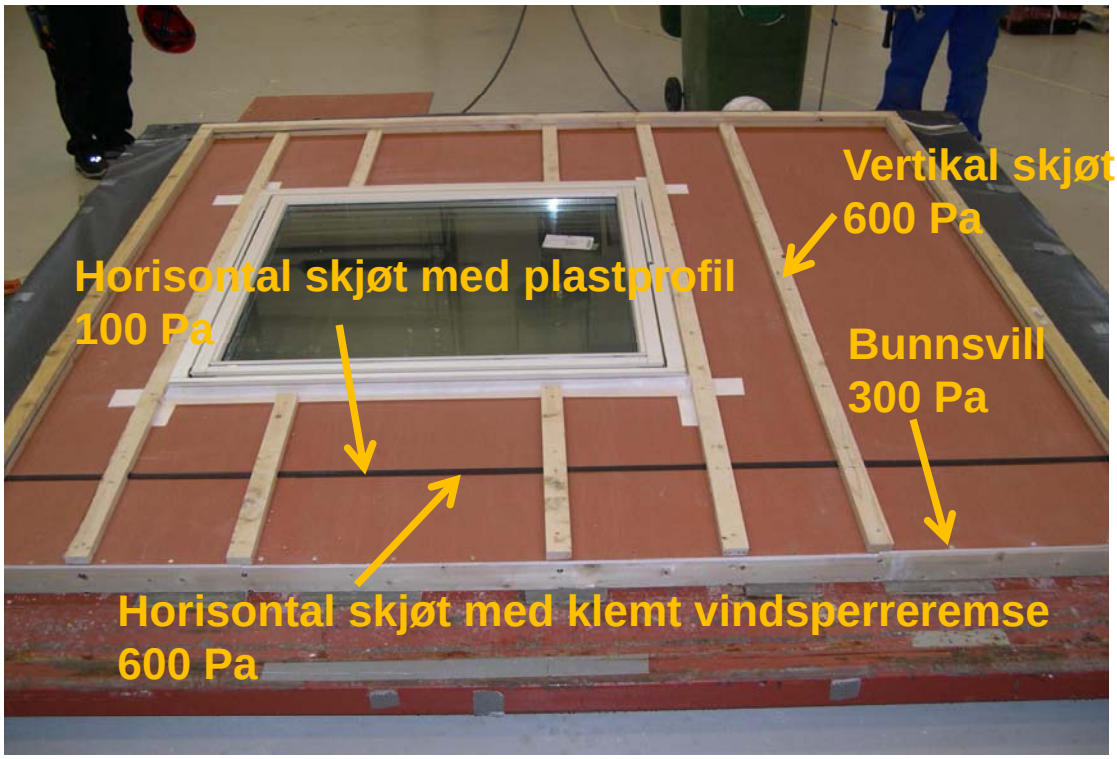
15 min nedsil 0 Pa trykkforskjell
10 min på hvert lasttrinn økende i sprang på 50 Pa



Asfaltimpregnert trefiberplate

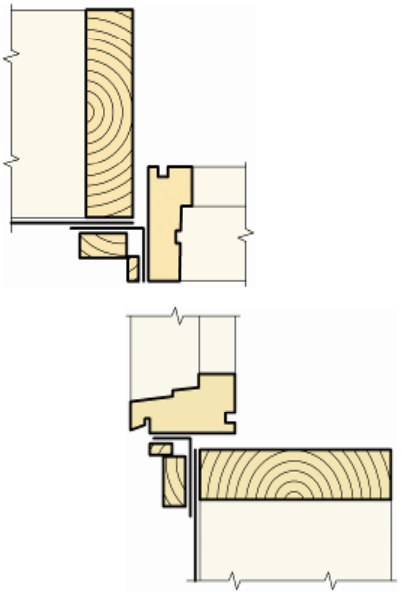


GU utvendig gipsplate



Vindsperre av polyetylenfibre

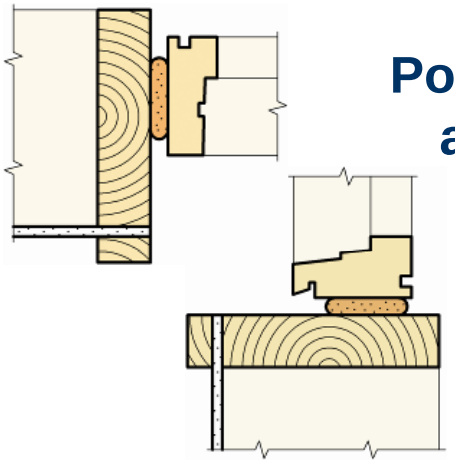
Vindsperrestrimler klemt med lekter rundt vindu

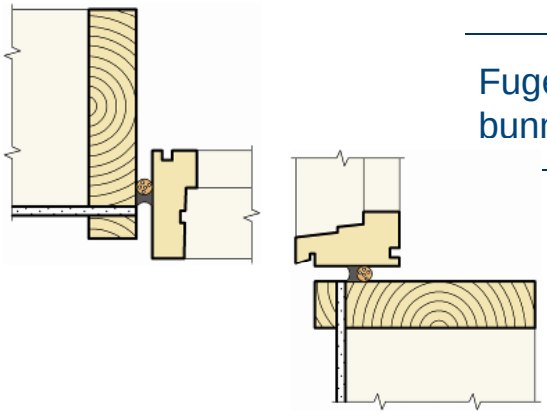


Vindsperre	Regntetthet i Pa			
	hjørne	under	over	side
Asfaltimp Trefiberplate *	0	0	0	600
Asfaltimp trefiberplate **	50	0	100	250
Gipsplate *	150	150	0	150
Spunnen duk av plast *	0	0	0	600

* vindsperreremse klemt utenpå plate/duk
** vindsperreremse klemt under plate

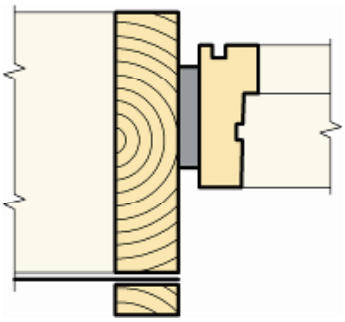
Polyuretanskum eller fugemasse av akryl mot bunnfylling rundt vindu

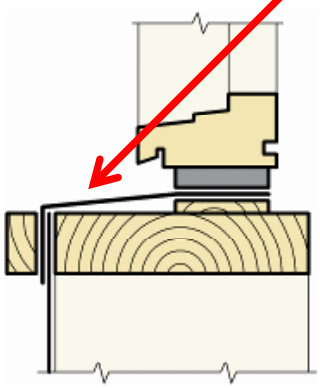




	Regntetthet i Pa			
	hjørne	under	over	side
Polyuretanskum	200	50	600	200
Fugemasse mot bunnfyllingslist	400	400	100	400

Ekspanderende fugebånd rundt vindu





	Regntetthet i Pa			
	hjørne	under	over	side
Eksp. fugebånd Med membran	100	50	600	600
Eksp. fugebånd Uten membran	600	150	600	600

Teknologi for et bedre samfunn