Vacuum Insulation Panels in Wood Frame Wall Constructions
Hot Box Measurements and Numerical Simulations

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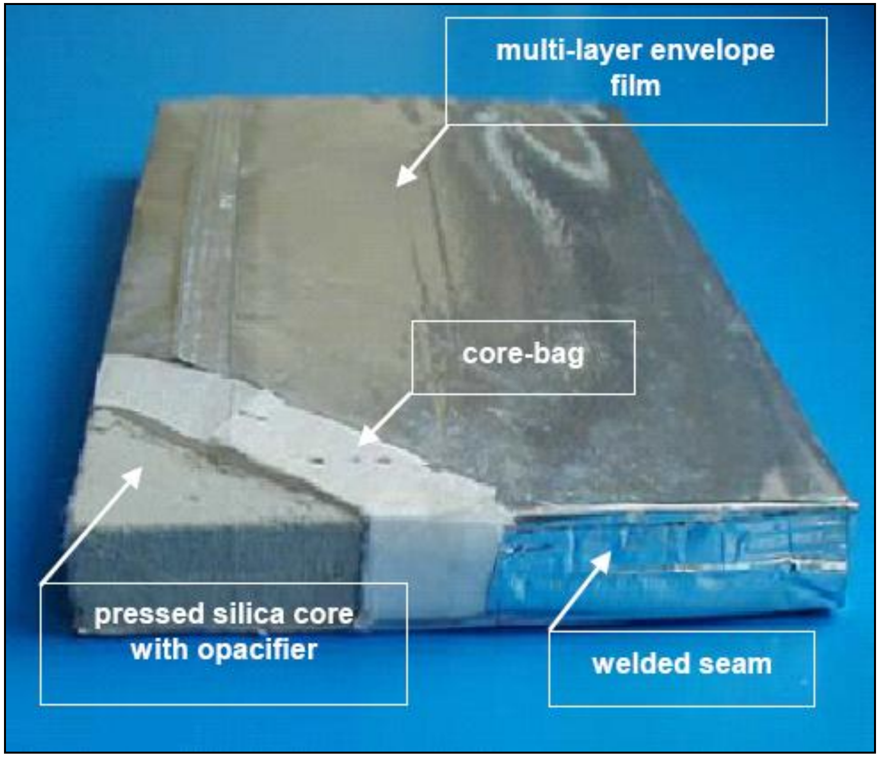
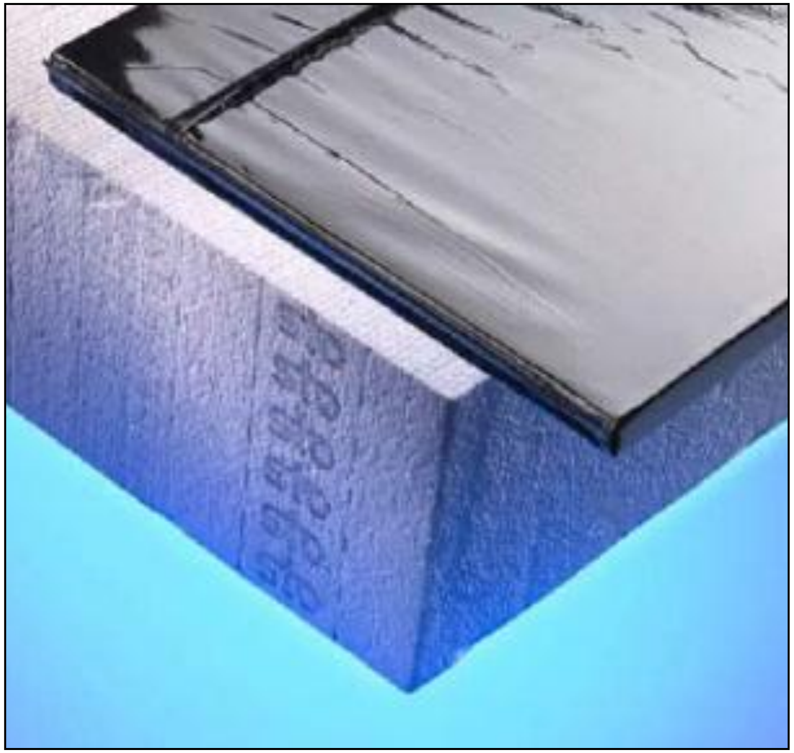
Background

- This work is part of the studies of VIPs within the research program *Robust Envelope Construction Details for Buildings of the 21st Century* (ROBUST)



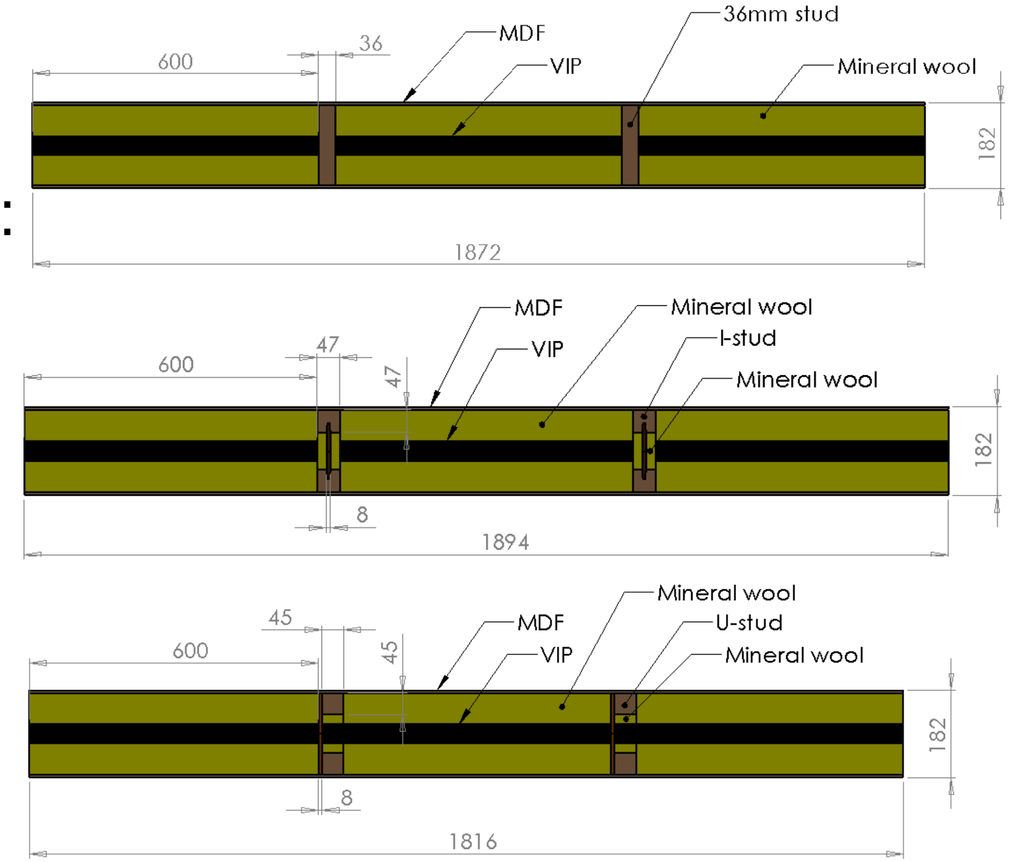
Simmler et al. 2005



Zwerger and Klein 2005

Objective

- Practical application of VIPs in slim wood frame wall constructions with low thermal transmittance (U-value).
- Compare thermal performance of walls with:
  - Standard wooden studs
  - I-profiled studs
  - U-profiled studs
- Compare hot box measurements and numerical simulations



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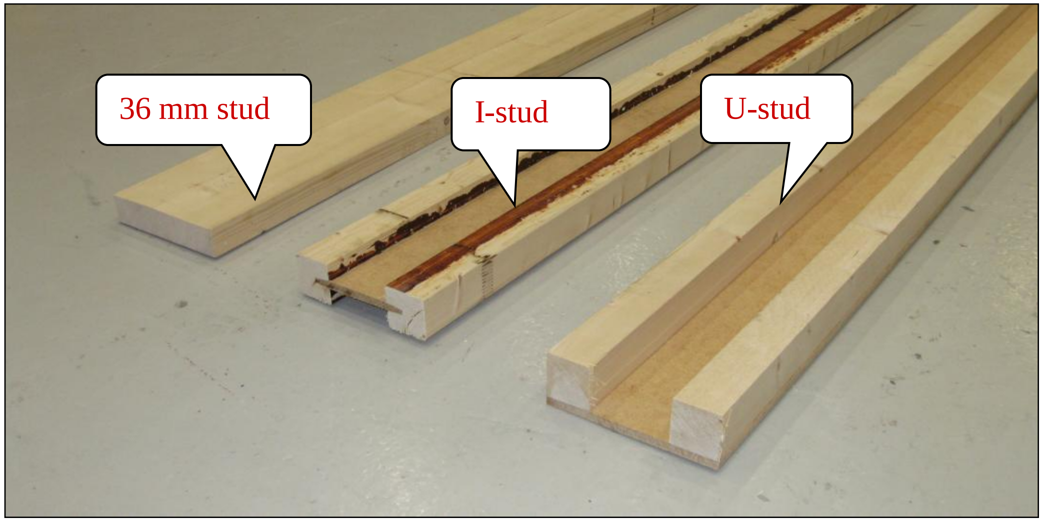
Test materials

- **Vacuum Insulation Panels**
  - Nom. dim.: 40 mm x 600 mm x 1000 mm
  - 0.1 mm multilayer foil (MF-2)
  - 0.3 mm fire retardant glass fibre

- **Studs**
  - 36 mm stud
  - I-stud
  - U-stud

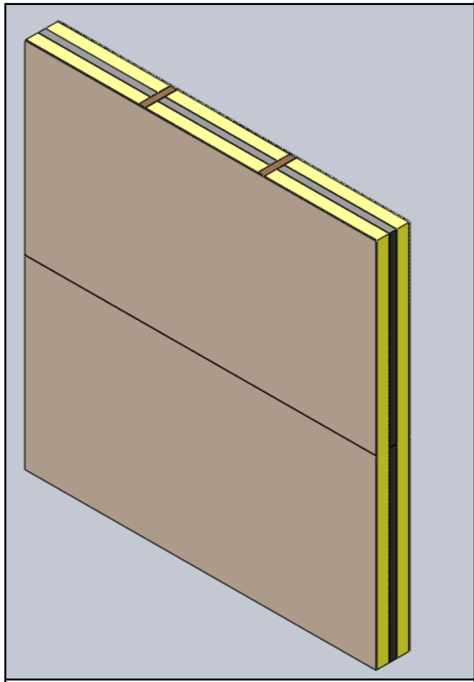


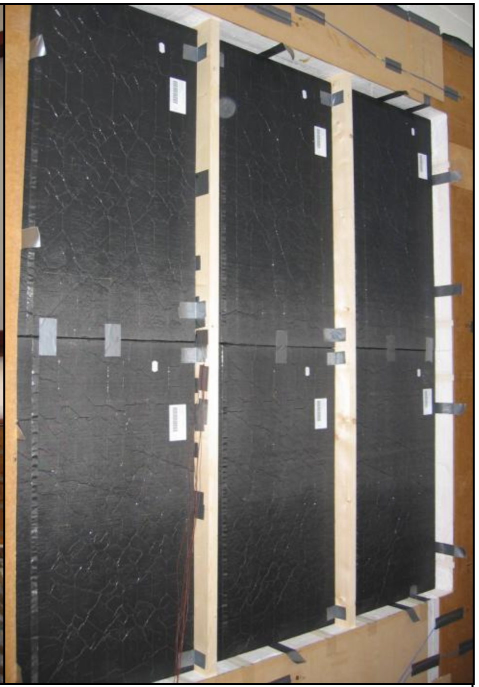
- **Mineral Wool**

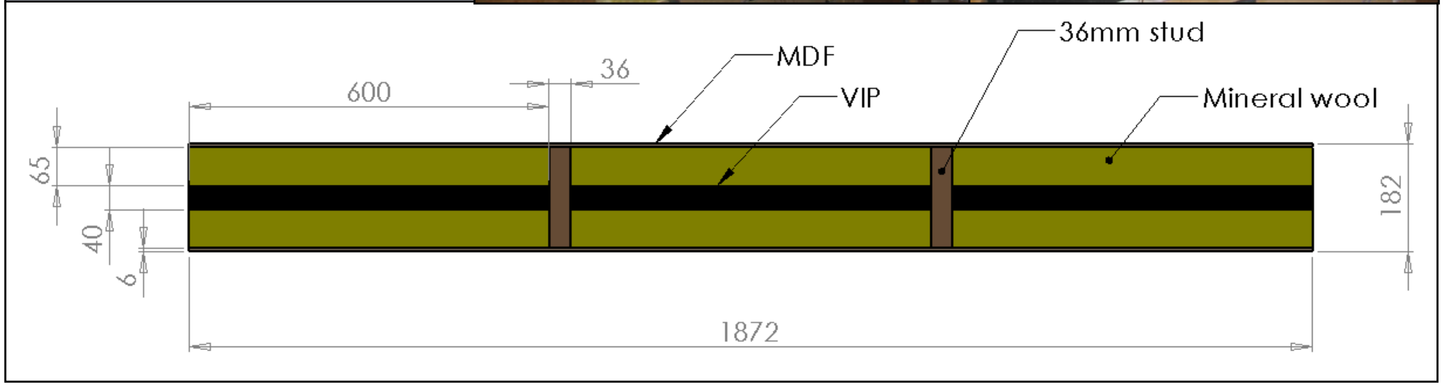
- **Medium Density Fibreboard**

Hot box measurements

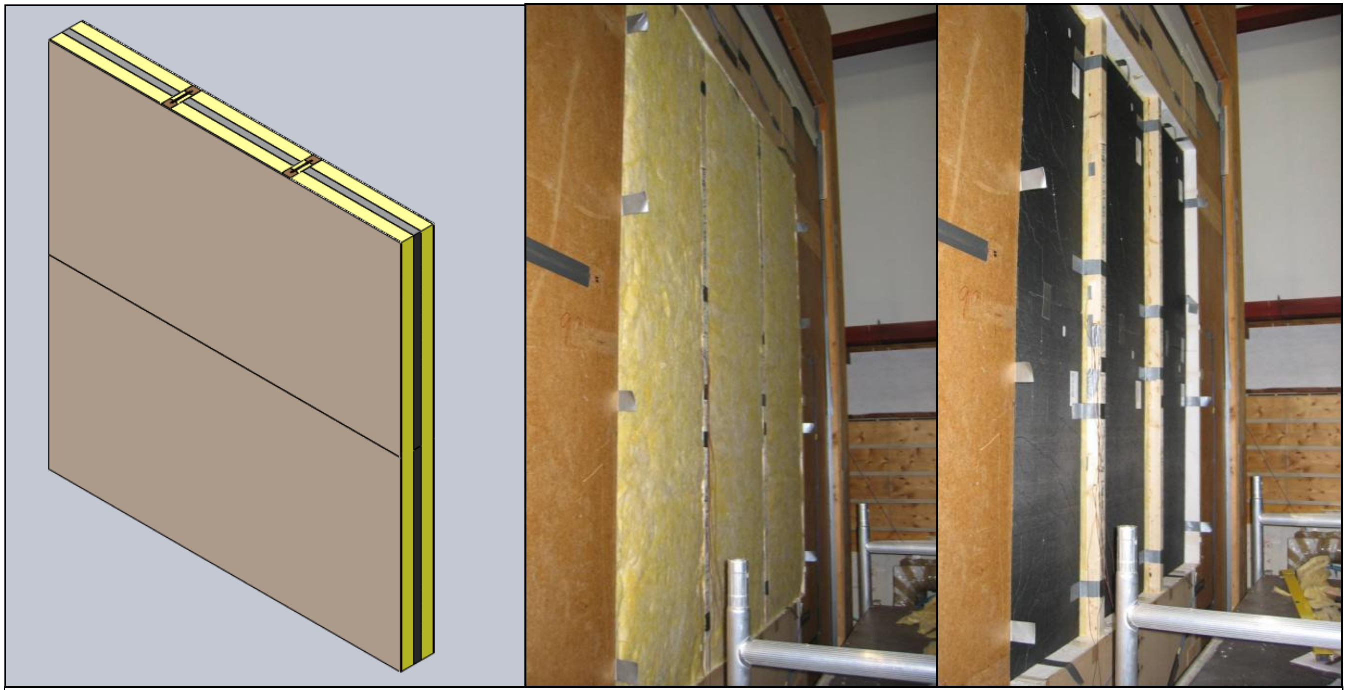
Wall with 36 mm studs

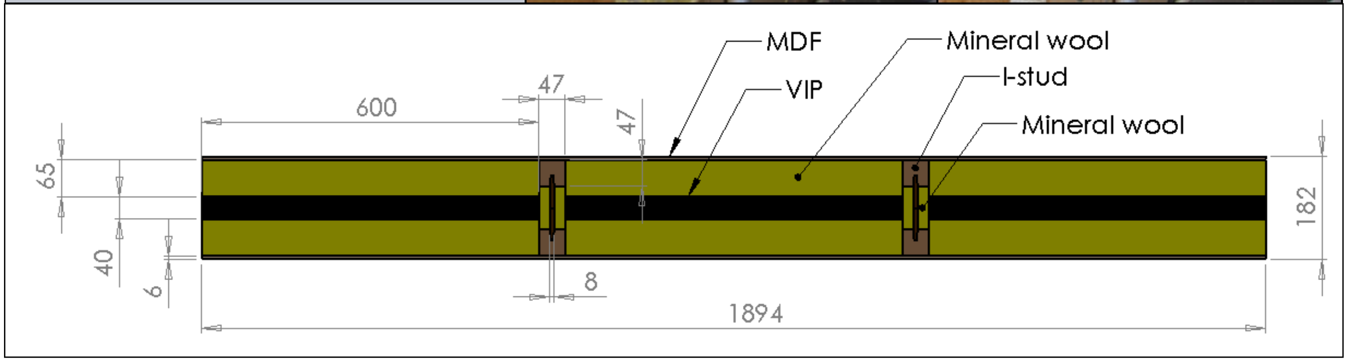




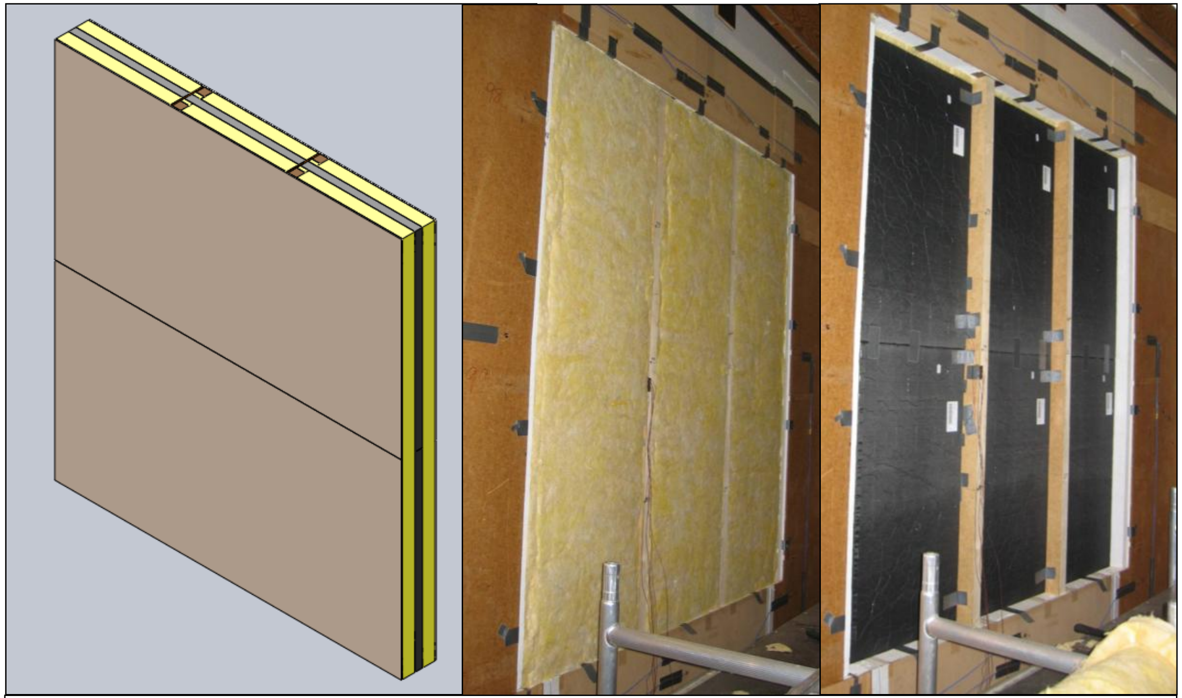


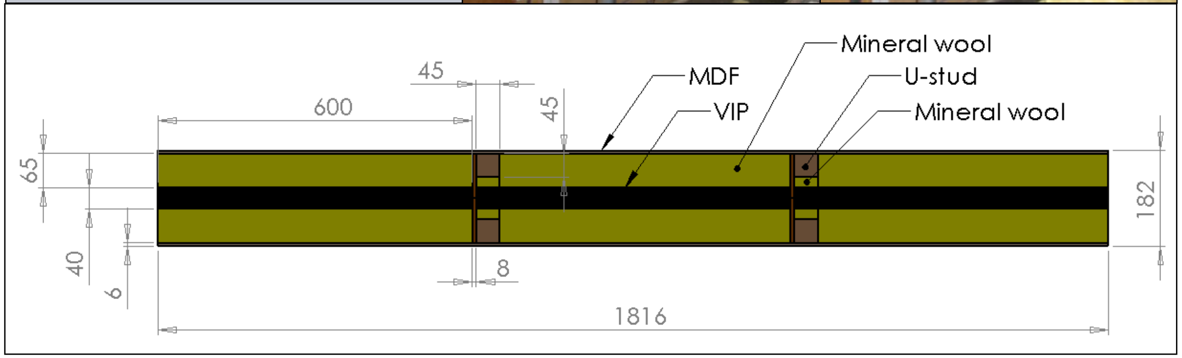
Wall with I-studs



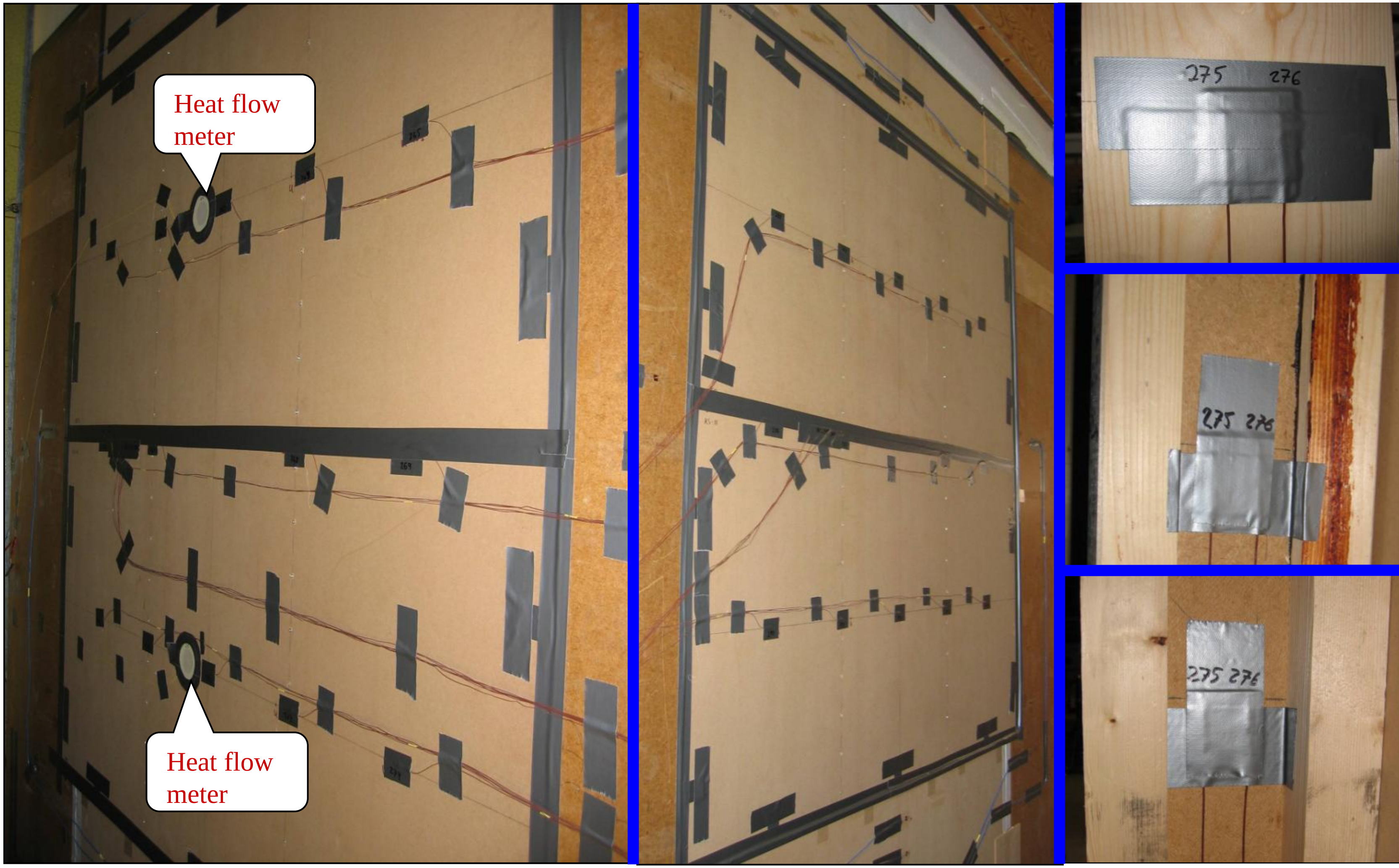


Wall with U-studs





Instrumentation



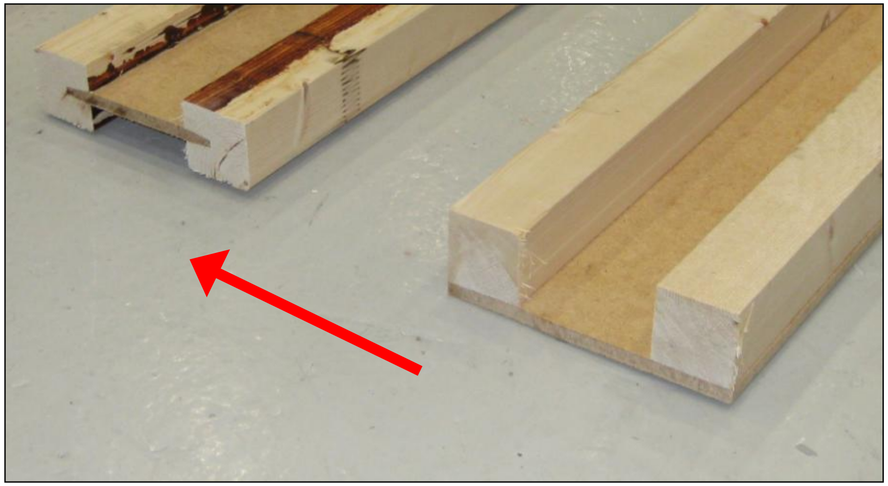
Numerical simulations

- 2D finite element program THERM
- Only thermal conduction
- Thermal surface resistance:
  - 0.04 m^2K/W at outdoor surface (0 ˚C)
  - 0.13 m^2K/W at indoor surface (20 ˚C)

Materials

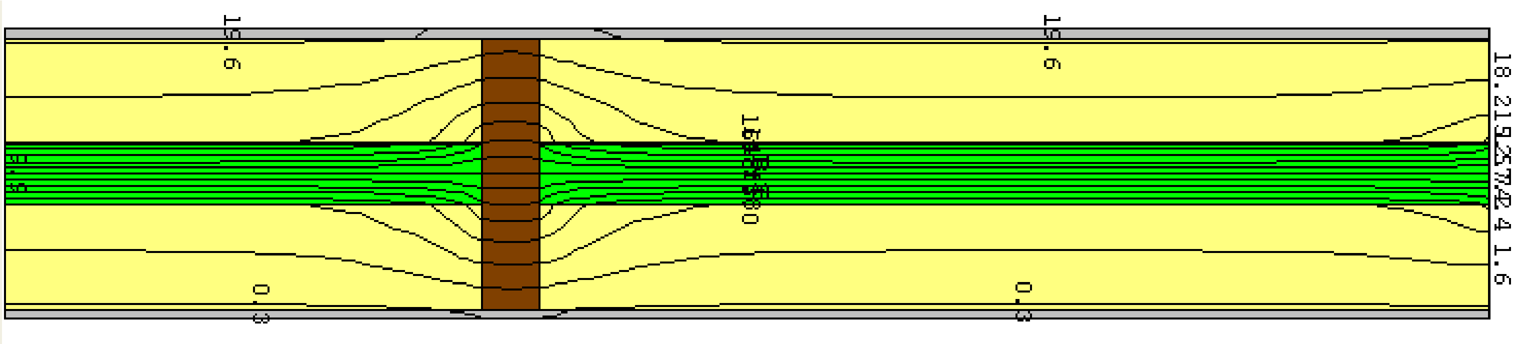
Item	Thermal Conductivity [W/mK]	Thickness [mm]	Reference/Comment
VIP core	0.0043	37.2	Thermal conductivity based on measurement of 2 VIP panels
VIP multilayer MF-2 type foil	0.54	0.1	Tenpierik and Cauberg (2007)
VIP fire retardant glass fibre material	0.31	0.3	va-Q-tec (2009b)
36 mm wood stud	0.10 (0.13)	36	Thermal conductivity of 0.10 W/(mK) is calculated from measured density and moisture content in 36 mm studs. The value in parenthesis (0.13 W/(mK)) is typical value for wood (NS-EN ISO 10456 2007)
Wooden flange in I-stud and U-stud	0.10 (0.13)	47 (I-stud) 45 (U-stud)	
Fibreboard in web of I-stud and U-stud	0.38	8	Thermal conductivity from measurement
Mineral wool	0.037	66	Glava (2008)
MDF	0.18	6	NS-EN ISO 10456 (2007)

Fibreboard measurement

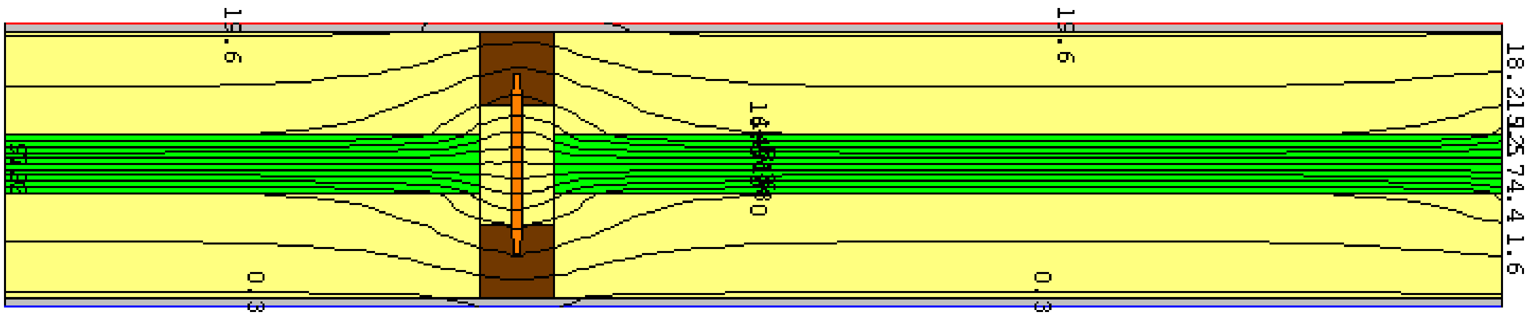


- Measured thermal conductivity in longitudinal direction: $\lambda_{fb\parallel} = 0.38$ W/(mK)

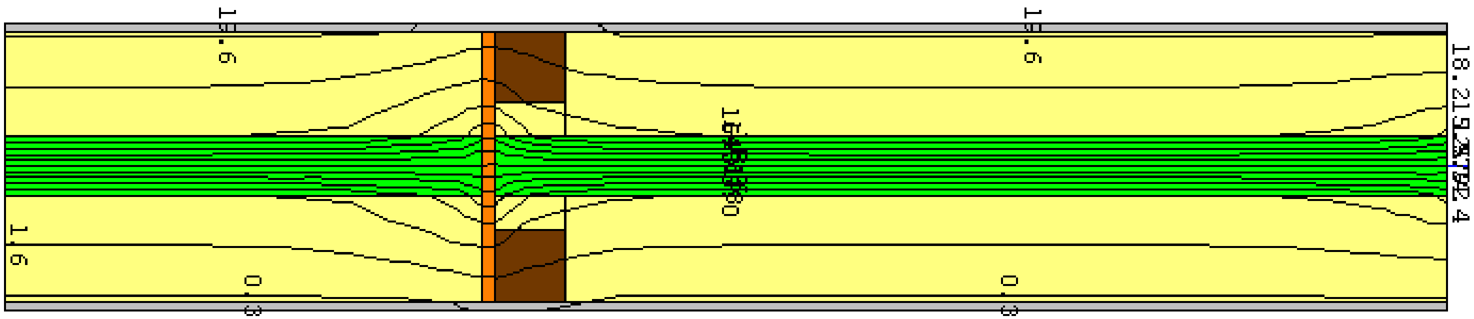
Temperature isotherms



36 mm stud



I-stud



U-stud

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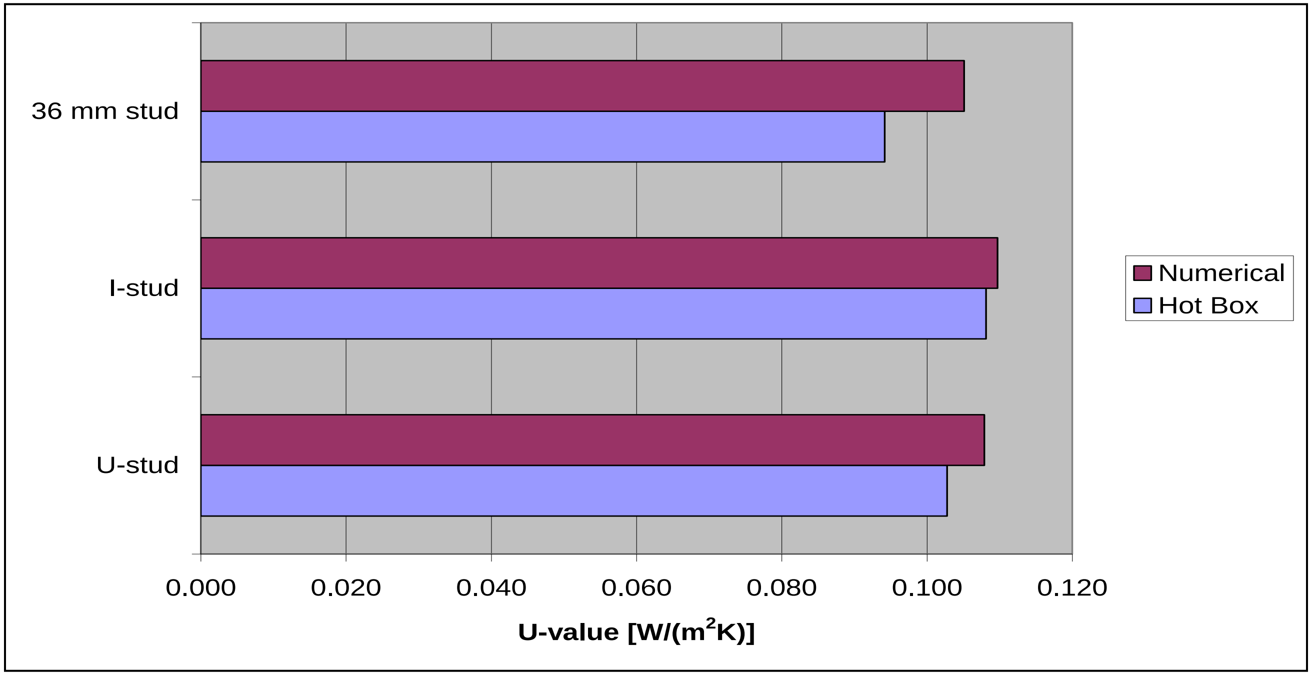
Results - Average for Wall with Studs

	Hot Box [W/m²K]	**Numerical** *) [W/m²K]	**Difference***) [%]
36 mm stud	0.094	0.105 (0.111)	11.6 (17.9)
I-stud	0.108	0.110 (0.112)	1.5 (3.7)
U-stud	0.103	0.108 (0.109)	5.0 (6.2)

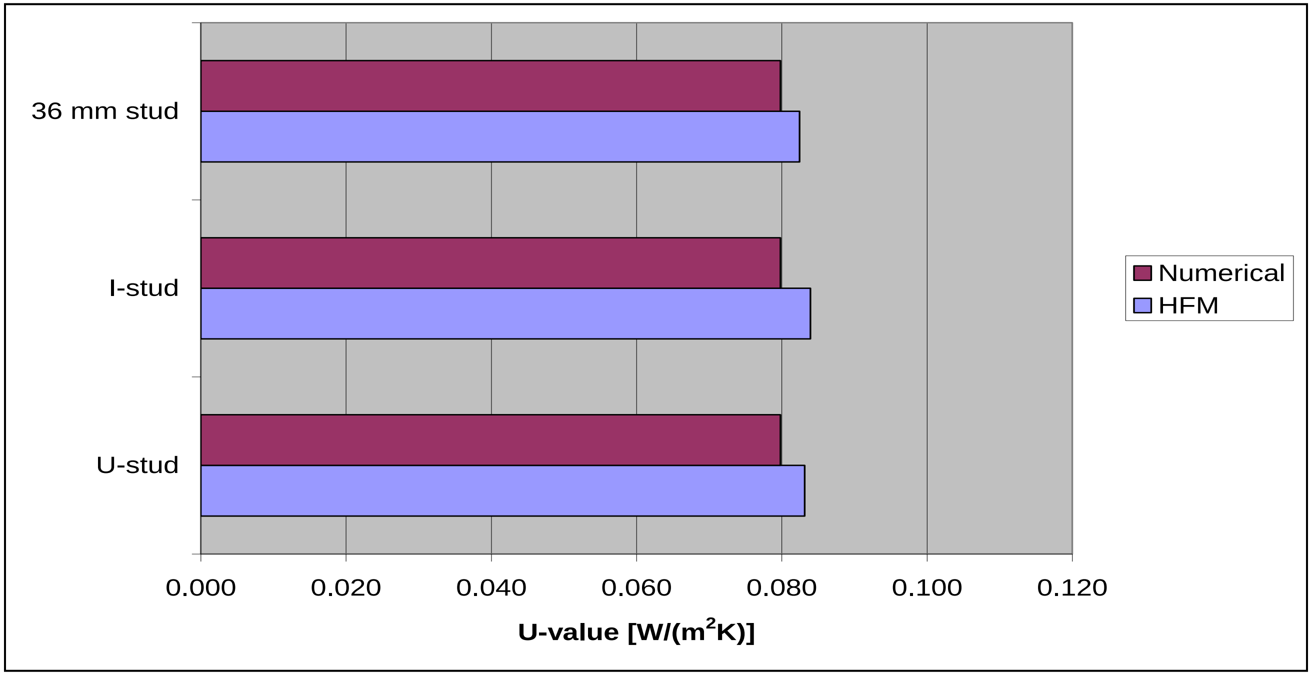
****) The effect of increasing the thermal conductivity of wood from 0.10 W/(mK) to 0.13 W/(mK) is shown in parenthesis.***



Results – Wall at Centre of VIPs

	Hot Box *) [W/m²K]	**Numerical** [W/m²K]	**Difference** [%]
36 mm stud	0.082	0.080	-3.2
I-stud	0.084	0.080	-4.9
U-stud	0.083	0.080	-4.0

) Wall measured at centre of VIPs with heat flow meters (HFM) in hot box.



Conclusions

- I-profiled and U-profiled studs were not as good as expected due to high thermal conductivity in the fibreboard of the web.

- Not flexible and easy to use VIPs in wood frame wall constructions due to the fixed dimensions.

- VIPs makes it possible to achieve slim wood frame wall constructions with low thermal transmittance (U-value), but good planning and workmanship is required.

- Good correlation between hot box measurements and numerical simulations when actual measured thermal conductivity values and dimensions were used in the simulations.

References

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