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Optimization of Window Installations During Deep Energy Building Retrofits Using Vacuum Insulation Panels

Authors: Cezary Misiopecki (presenting),
Jan Kosny, Ali Fallahi, William DuPont, Arild Gustavsen

FraunhoferCSE, Building Energy Efficiency Group, Boston, MA, United States

Norwegian University of Science and Technology, Trondheim, Norway
SINTEF Building and Infrastructure, Trondheim, Norway

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Presentation agenda

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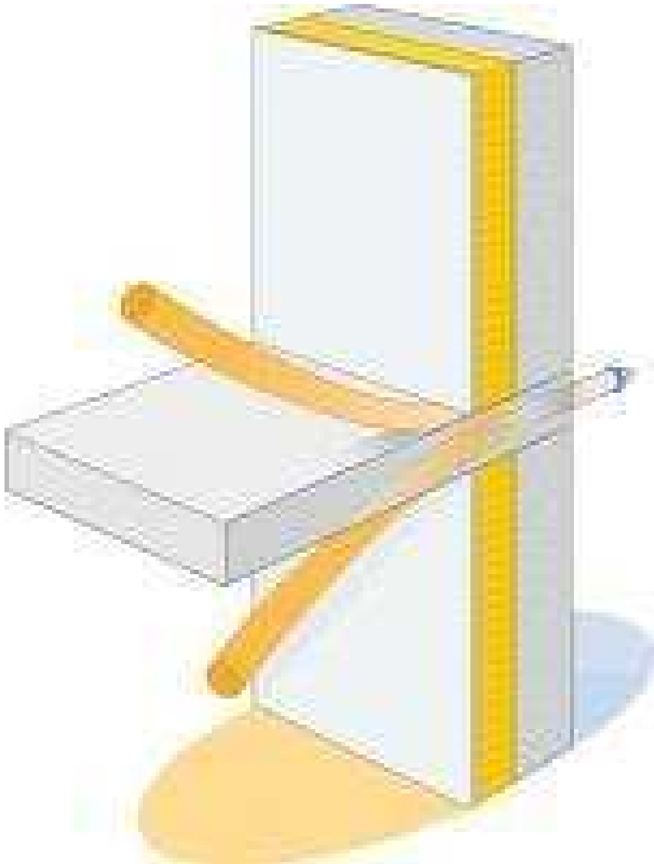
2. Scope
3. Geometry
4. Numerical procedures
5. Results and discussion
6. Conclusions
7. Further work



1. Introduction

- Buildings accounts for over 40% of primary energy use and for around 24% of greenhouse gas emissions,
- Up to 60% of total energy losses through building envelope may come from windows.

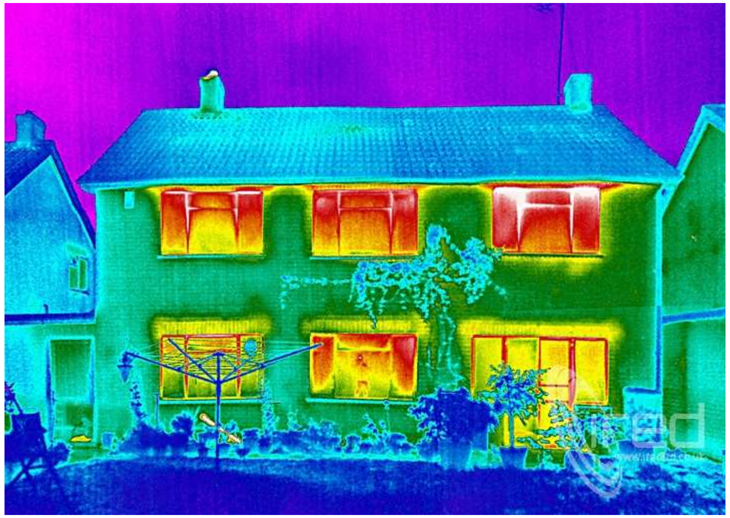


FIG 1.
Thermography picture showing losses from windows.
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-> Therefore improved fenestration products have a huge potential to provide energy savings.

1. Introduction

- **Thermal bridge**
  constructions which give rise to changes in heat flow rates and surface temperatures compared with those of the unabridged structure

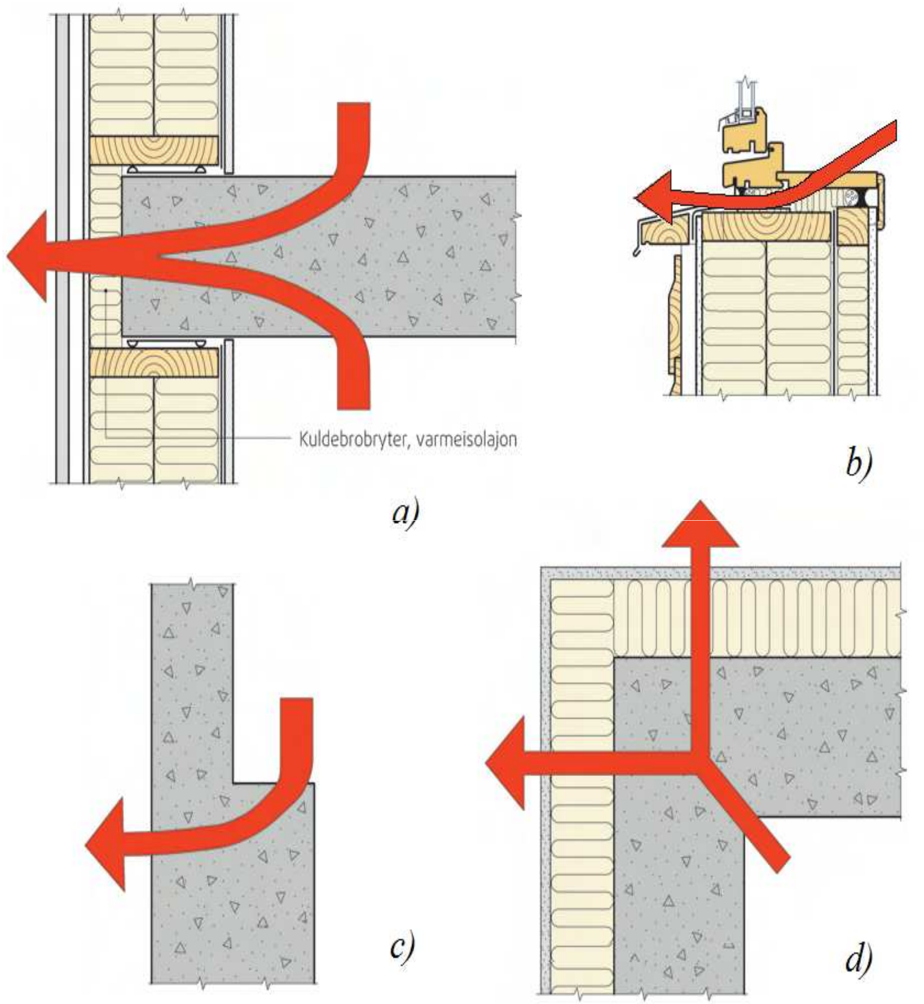
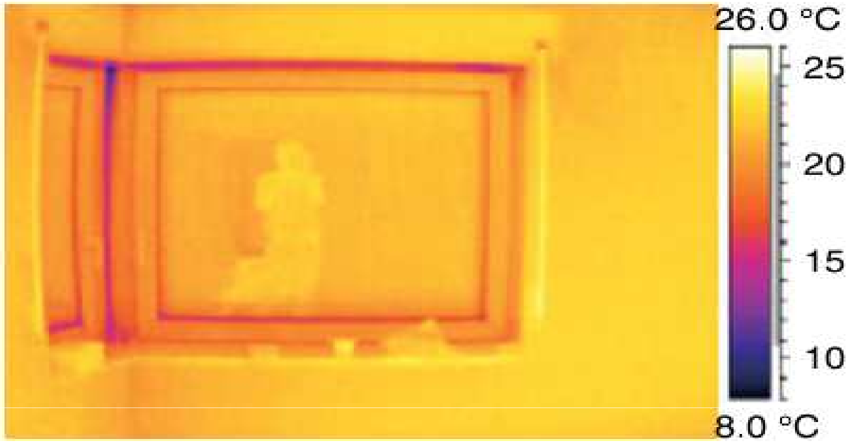


FIG 2.
Thermal bridging effect on different building components.

1. Introduction



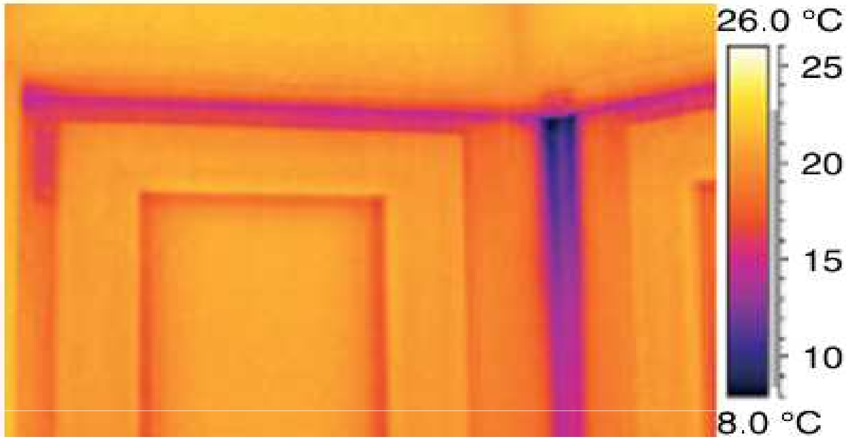


FIG 3.
Thermography picture showing thermal bridging on window wall connection surfaces.

- Development in windows and wall technology

  windows < **0.8** W/m²K
  walls < **0.15** W/m²K

thermal bridge free construction ≤ **0.01** W/mK

- One argument that has not yet been explored in the literature is influence of position of window in opening on thermal performance

- Thermal bridges can be responsible for up to 40% of thermal losses through the building envelope

1. Introduction

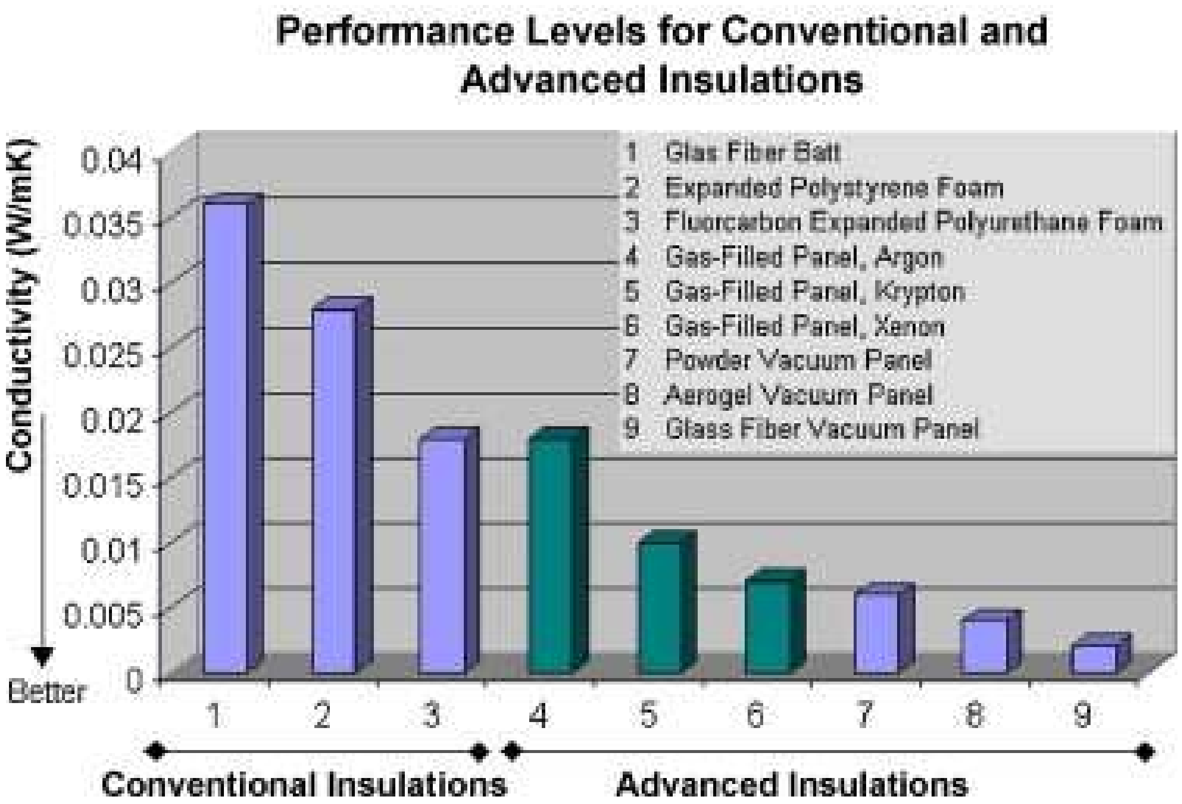


FIG 3.
Insulation thermal properties comparison.

2. Scope

- To determine the optimum position (to minimize the Linear Thermal Transmittance around the windows) to install windows (in thick walls retrofitted with convectional insulation and VIPs).

LIMITATIONS:

- study does not investigate the air leakage or water drainage of the modeled solutions,
- air flow velocities next to individual surfaces were not simulated in detail, and instead simplified heat transfer coefficients were used,
- study only modeled the window sill and the bottom edge of the window opening

3. Geometry

Table 1 - Materials, Dimensions and Properties of Wall Systems

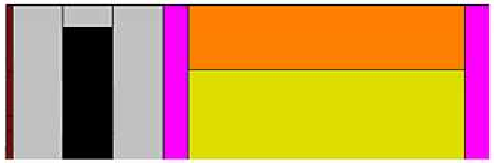
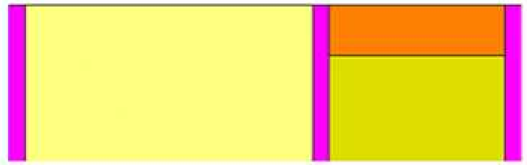
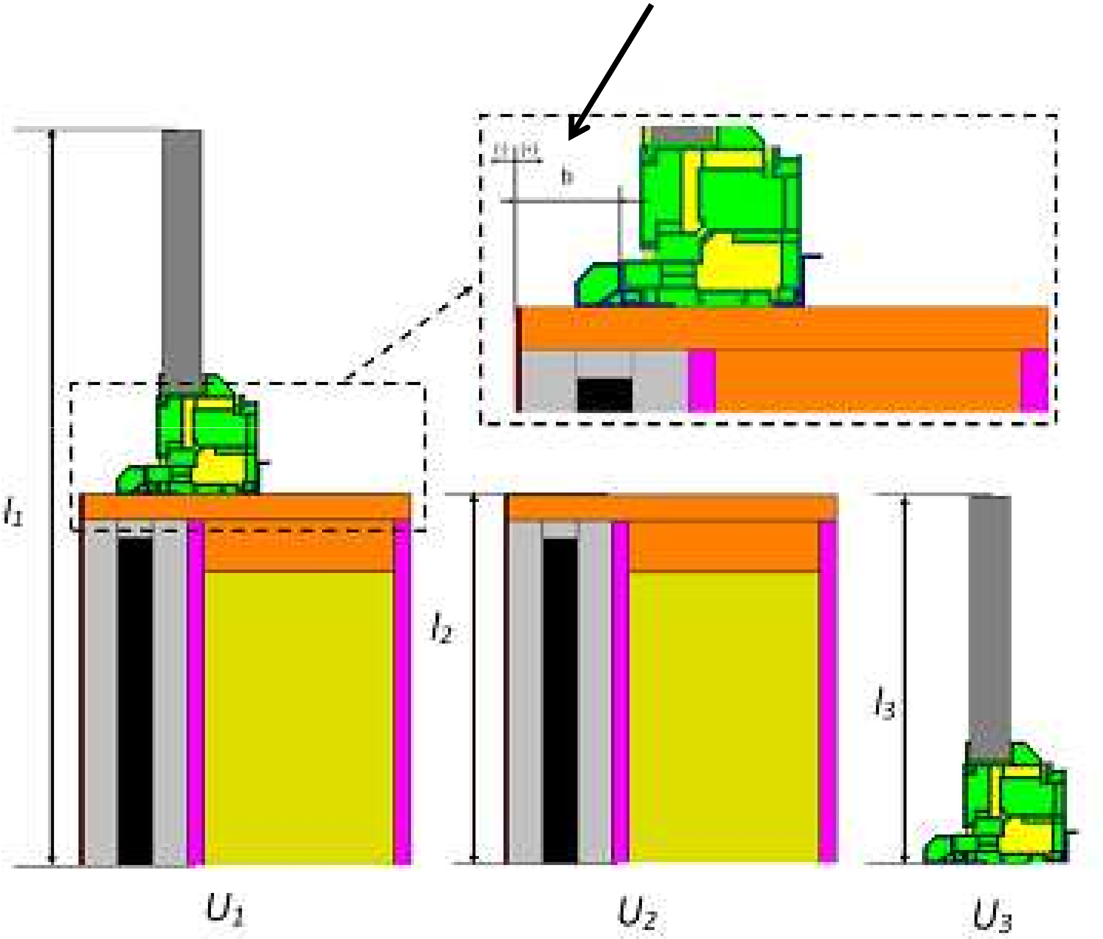
Wall type	Wall retrofitted with VIP panels		Wall retrofitted with conventional insulation	
Geometry				
Construction	Material (from inside to outside)	Thickness [mm]	Material (from inside to outside)	Thickness [mm]
	Drywall Glass Fiber Batts Drywall EPS VIP EPS Cement plaster	12.7 139.7 12.7 25.4 25.4 25.4 3	Drywall Glass Fiber Batts Drywall XPS Drywall	12.7 139.7 12.7 219.71 12.7 25.4
Total thickness		244		423
Wall U-value [W/(m²K)]	0.09		0.09	

FIG 4. Wall construction comparison .

3. Geometry

- Dimension “b”



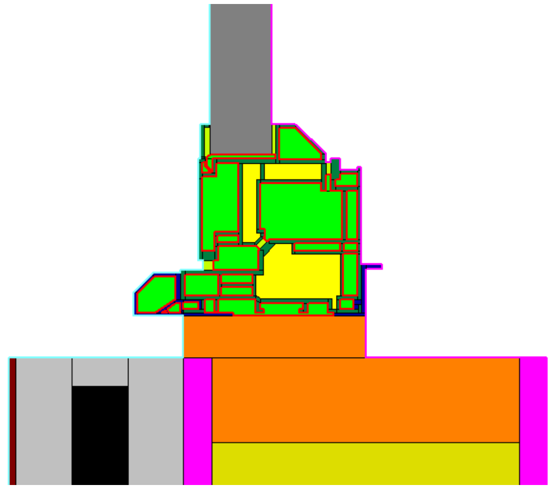


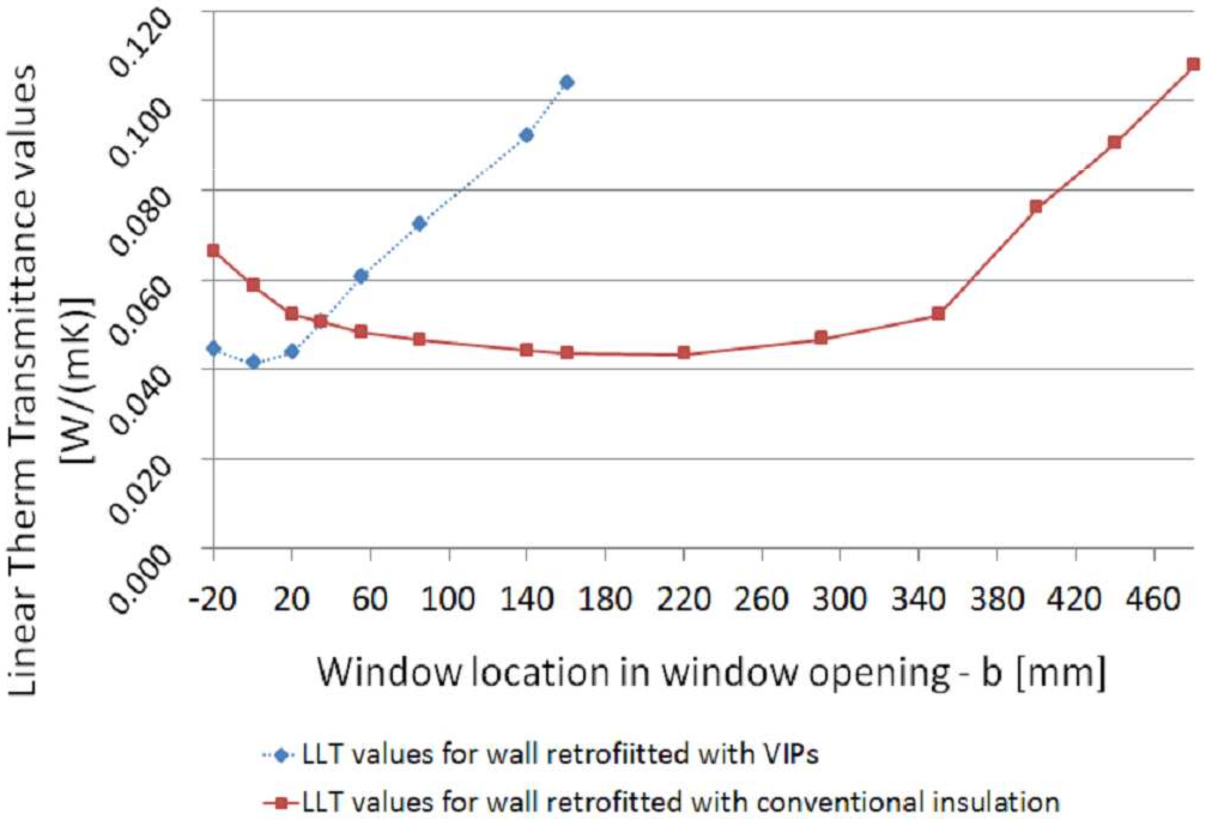
FIG 5. THERM Model of the Window and VIP Wall System.

4. Numerical procedures

- 2D heat flow simulation tool was used – THERM 6.0.
- A number of simplifications were made
  - simplified boundary conditions were used,
  - several intermittent layers were assumed continuous and simplified,
  - thermally insignificant components were not included such as the window flashing and the vapor barrier,
- The Energy Error Norm for all simulations was kept around 6% which yields U-Factor uncertainty of less than 1% based on THERM documentation

5. Results and discussion

- The first set of simulations calculated the thermal performance of 14 different window installation – theoretical cases,

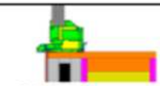
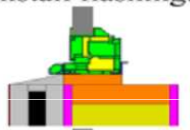
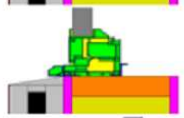
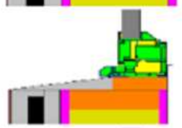
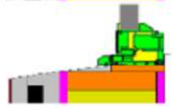


- window installation has an influence on thermal properties,
- VIP case more sensitive for window possition,

5. Results and discussion

- Flashing slope 5:1
- Additional wood framing over VIP panels
- “sitting block ” added in few cases
- No flashing modeled

- Substantial reduction of Liner Thermal Transmittance when window in optimal position

Position in window opening b [mm]	Geometry	Linear thermal transmittance Ψ [W/(mK)]	Position in window opening b [mm]	Geometry	Linear thermal transmittance Ψ [W/(mK)]
00	 No changes need in order to install flashing.	0.044	00		0.059
+ 85 A		0.076	+35C		0.058
+ 85 B		0.070	+35 D		0.057
+ 160A		0.103	+55C		0.062
+160B		0.104	+55 D		0.060
			+85C		0.066
			+440E		0.077
			+440 F		0.080

5. Conclusions 1/2

- If water drainage and installation details are not considered the most energy efficient window position is roughly in the middle of retrofit insulation (b = 0 mm for the wall retrofitted with VIPs, and b = 160 mm for the wall retrofitted with conventional insulation)

- The optimum location to install a window in the window aperture of a wall retrofitted with conventional insulation is within 55 mm from the exterior face of the wall.

5. Conclusions 2/2

- Although the heat transfer through the window-wall area in a conventionally retrofitted wall system is not as sensitive to the location of the window in the wall aperture, walls retrofitted with VIP systems have a 30% lower Linear Thermal Transmittance when comparing the optimal window installation locations

5. Further work

The work presented in this paper is a good starting point for further investigation of window–wall inter-face properties. Further work might focus on:

- Model all sides of the window-wall interface including the window jambs and the head,
- Model the window-wall interface in three-Dimensions to capture influence of the corners of the window and framing of the window aperture in the wall

Thank you

http://bravoremodeling.com/

Questions and comments are welcome.