Patrycja Kochaniuk, July 2012
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Roof insulation

It is commonly recognized that the insulation at attic floor is generally the easiest and the most cost-effective way for roof insulation. Rafter insulation should be considered only if the attic space is habitable, otherwise the whole attic would be unnecessarily heated. In the case study house the attic space is limited with its hipped end, so it is assumed it will not be adapted. Thus the ceiling insulation is considered the best solution.

a. Insulation at attic floor

Insulating between the joists can bring the U-value of the ceiling to about 0.4W/m^{2}K with the material's thermal conductivity of 0.04W/mK and additional layers can be installed on top. Insulation should not be squeezed, so if it is not rigid and the attic is going to be used as a storage space, the floor needs to be raised. This usually requires counter joists installed across original ones with insulation between them and decking boards on top.

Attic space ventilation ensures that condensation does not occur, so the vapour control is not necessary (Fig.1). However, it is also important to provide an air tight barrier at the ceiling level. When using traditional insulating materials, like mineral wool, an air tight membrane can be installed under the timber joists. To facilitate this, the existing ceiling plasterboard needs to be replaced. Also all penetrations (cables etc.) need to be carefully sealed. Another, simpler approach is to install the open cell spray foam insulation from above, leaving the existing plasterboard in place. This would have to be done once all the wiring is in place and the cables should be extended above the insulation in the attic. The foam would seal all the openings, make the ceiling air tight and provide insulation in the same time. It is more expensive than other more traditional materials, but eliminates work related to installing the membrane and new plasterboard. Also, when sprayed between the joists, it does not necessarily require installation of flooring boards for storage purposes. A closed cell, non breathable insulation materials like phenolic board are more difficult to deal with, as explained below and should be avoided if possible.

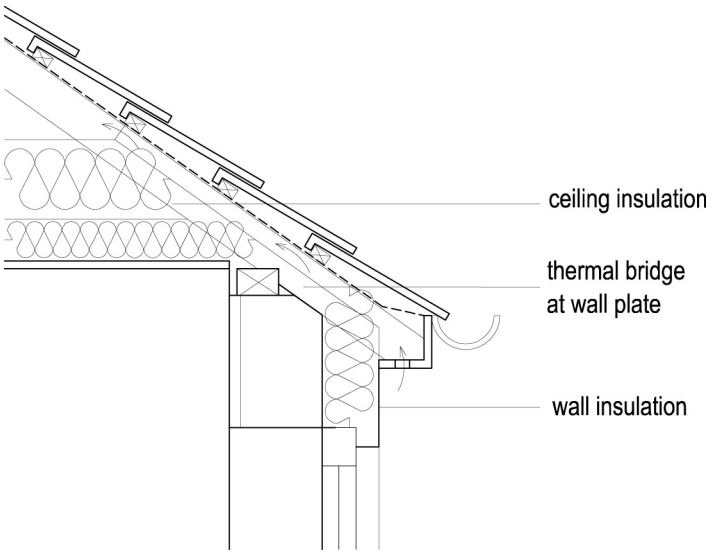
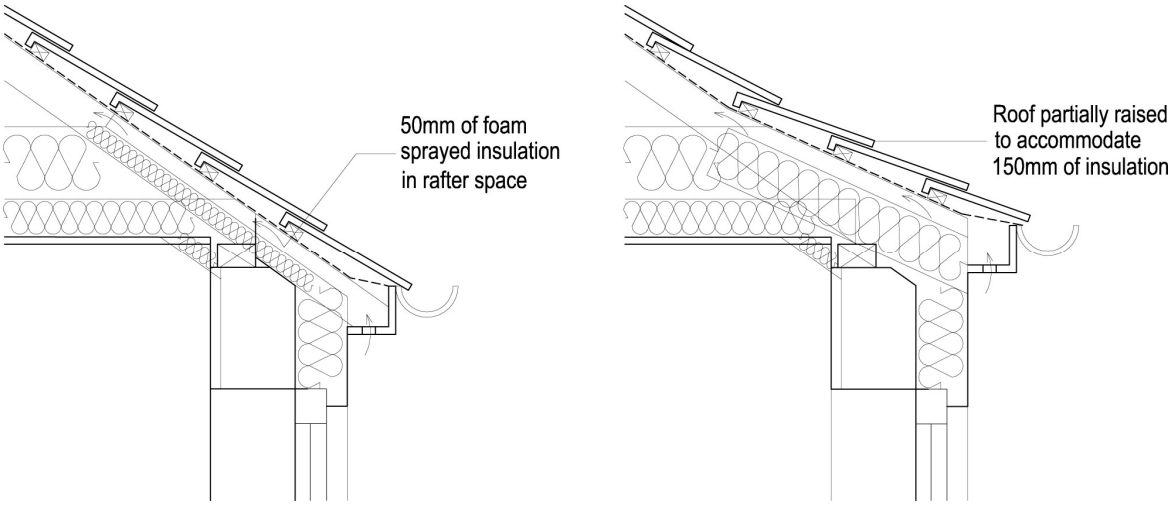


Figure 1. Thermal bridge at wall – ceiling junction



A. Insulation between existing rafters *B. Part of the roof raised*

Figure 2. Wall – ceiling junction thermal bridge reduced

Adding insulation at ceiling in the existing geometry of joists and rafters is creating a thermal bridge at the wall plate (Fig.1). It can be partially mitigated by installing insulation in the rafter space at the junction of wall and ceiling floor. If an existing old non-breathable felt is left in place – a ventilation cavity would need to be created. Additional insulation could also be added internally – at the wall to ceiling junction (Fig.2A), or a part of the roof could be raised to accommodate more insulation in the rafter space (Fig.2B). The simplest method of dealing with recessed light fittings would be to eliminate them completely in the first floor ceiling, but if they are necessary – the air tightness barrier should be created above the fixture enclosure.

b. Phenolic insulation between timber joists

When a closed cell, non breathable insulation material like phenolic board is installed between timber joists, it will not allow the water vapour through, so if any moisture gets through the barrier (for example if incorrectly fitted) – it will get to the timber, which could cause its damage over time.

The smaller the thermal conductivity of the insulation material, the bigger of a thermal bridge the timber joists are becoming and the bigger is the risk of water condensation in structural wood. Thus, phenolic insulation should only be installed between structural timber if there is limited space not allowing for installation of other breathable insulation material and under a condition that the water vapour (and air tightness) barrier can be installed as a continuous layer and will not be damaged during the lifetime of the installation.

c. Calculations

The simplest upgrade in option A involves installing 100mm of spray foam directly between the existing joists and about 50mm between rafters at wall plate. The associated cost covers installation

of insulation only. Option B shows calculations for additional 200mm of sprayed foam between added counter-joists and the same 50mm at wall plate (Fig.2A). Additional cost includes installation of counter joist timbers and more insulation. In option C the wall plate area is additionally insulated with 150mm of sprayed foam in the raised section of roof (Fig.2B). Extra work involves removing and re-fitting the bottom layers of roof tiles and replacing that part of the membrane. Option D adds an additional 100mm of insulation on the floor. The cost of new soffit and fascias is not included in calculations below as they are not directly connected with thermal upgrade.

		(1)	(2)	(3)	(4)	(5)	(6)
		U-value [W/ m^2/K]	Heating Energy [kWh/ m^2/y]	Saved energy [kWh/ m^2/y]	Capital Cost [€]	Cost/TFA [€/m^2]	Saved kWh/ m^2/y per 1€
	Base - no insulation	2.30	394				
A	100mm spray between joists, 50mm between rafters at wall plate	0.48	326	68	€790.87	€9.09	7.480
B	100mm spray between joists + 200mm above joists, 50mm between rafters at wall plate	0.25	317	77	€2,107.47	€24.22	3.18
C	100mm spray between joists + 200mm above joists, 150mm between rafters at wall plate	0.17	315	79	€2,560.33	€29.43	2.68
D	100mm spray between joists + 300mm above joists, 150mm between rafters at wall plate	0.14	314	80	€3,014.33	€34.65	2.31

Table 1. Ceiling refurbishment options

d. References

EST (2011) *Sustainable refurbishment* [Online]
Available at: http://www.energysavingtrust.org.uk/Publications2/Housing-professionals/Refurbishment/ Sustainable-Refurbishment-2010-edition (Accessed: 8 May 2011)
EST - Energy Saving Trust