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Single leaf wall Insulation.

The case study single leaf wall can either be insulated internally or externally, both options are described below.

a. Internal insulation

The most common internal insulation material is currently a rigid insulation board – a layer of phenolic insulation with attached plasterboard. The boards are either fixed to the wall using adhesive and mechanical fixings, or nailed to 25mm softwood battens. The vapour control is built in the system in the form of a foil at the back of the boards. Another approach includes installing insulation between the timber battens fitted to the wall and applying a vapour control membrane followed by the plasterboard. Mineral wool was used in the past, but currently it is recognized that it is not the best solution for vertical insulation as it is prone to sagging and collapsing when in contact with moisture. Natural materials, such as hemp wool or woodfibre boards can be used more successfully, although they are more expensive. However, such installation would require about twice as much depth of the insulation comparing to the phenolic insulated plasterboard (thermal conductivity of woodfibre is 0.04 W/mK, comparing to 0.02 W/mK for rigid phenolic board). The necessary vapour membrane can act as an air tightness barrier, but its installation in a continuous layer proves to be problematic, as explained below.

First disadvantage of internal insulation includes reducing the internal area of the house (in case of existing houses it means decreasing the area that the homeowner has already paid for). Another drawback is connected with unavoidable thermal bridges (for example at junctions of internal walls or floors with the external wall), that not only weaken the thermal performance of the whole house, but also could cause condensation on the worse insulated building elements leading to structural damage.

There is a common problem recognized with the interstitial condensation in internally insulated walls, which can lead to mould growth and deterioration of the insulation. It is usually caused by the incorrect installation of a vapour barrier, when the sheets are not continuous or it is punctured by building services (pipes, electrical sockets). It can also be damaged for example by nails installed during the building occupancy (for hanging things on the walls). It can be addressed by a careful design and installation of a vapour barrier. The joints between the vapour control sheets and connections with floors, ceilings and window reveals can be taped and sealed, while the problem with its penetration by services can be addressed by introducing an internal service zone in a form of a void created in front of the vapour barrier (Harris and Borer, 2005), as shown in Fig.1.

However, introducing a service zone would impact the most important advantage of internal insulation, which is the low cost of its typical installation comparing with external insulation. In the past, issues connected with addressing thermal bridging and problems with keeping a continuous layer of vapour barrier have not been addressed, thus the cost of internal insulation have been significantly lower.

Internal insulation is also lowering the thermal mass of the concrete walls, which can be seen either as a positive (because the house could possibly be heated quicker) or on the contrary – as a drawback (because it will not keep the heat as well as exposed walls insulated externally), depending on the pattern the house will be used and the heating method.

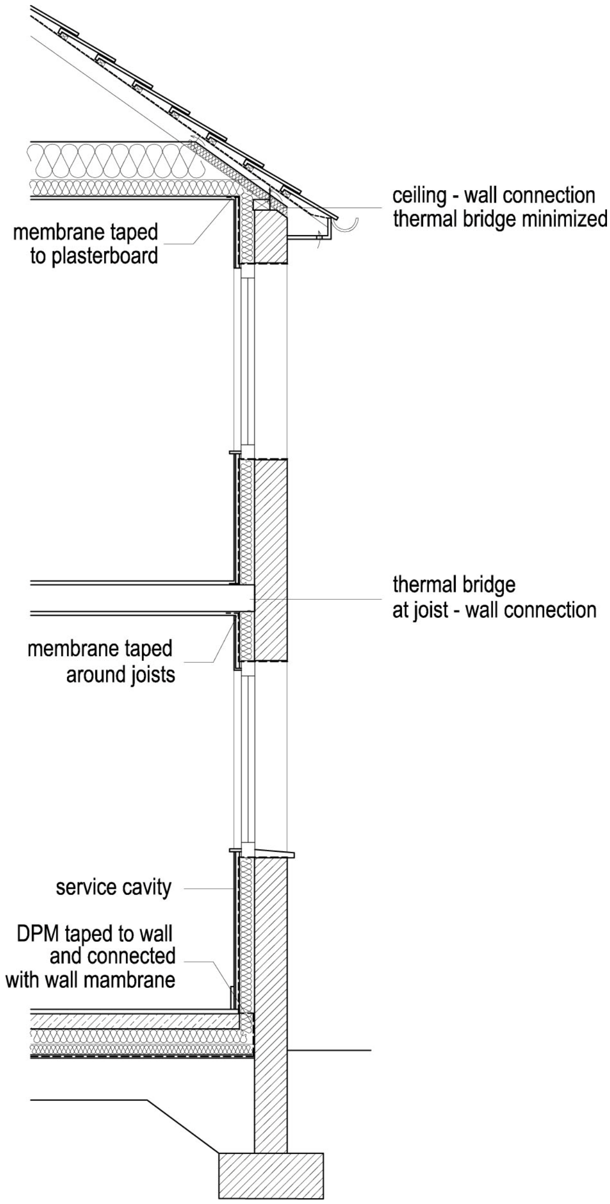

Figure 1. Section through internally insulated external wall

b. External insulation

External Wall Insulation (EWI) systems consist of an insulation layer, fixed to the external surface of the wall, followed by a reinforcing mesh and a finish render or cladding. Wet render systems have either a thick sand-cement render applied over a wire mesh, or a thinner polymer based render applied to a lighter glass reinforced mesh (EST, 2011). The dry systems use cladding systems as a finish (timber panels, stone or clay tiles etc.) There is a number of different insulation types used, but the most common for standard application (and cost – effective) is the expanded polystyrene (EPS) with thermal conductivity of 0.04W/mK for standard white boards and 0.031 W/mK for enhanced grey ones. If the thickness of insulation is an issue, phenolic insulation can be used with thermal conductivity of 0.02W/mK. In case of masonry with moisture issues the best application would be mineral wool or natural materials with ability to transfer the moisture to outside. Fig. 2 shows a typical external insulation application.

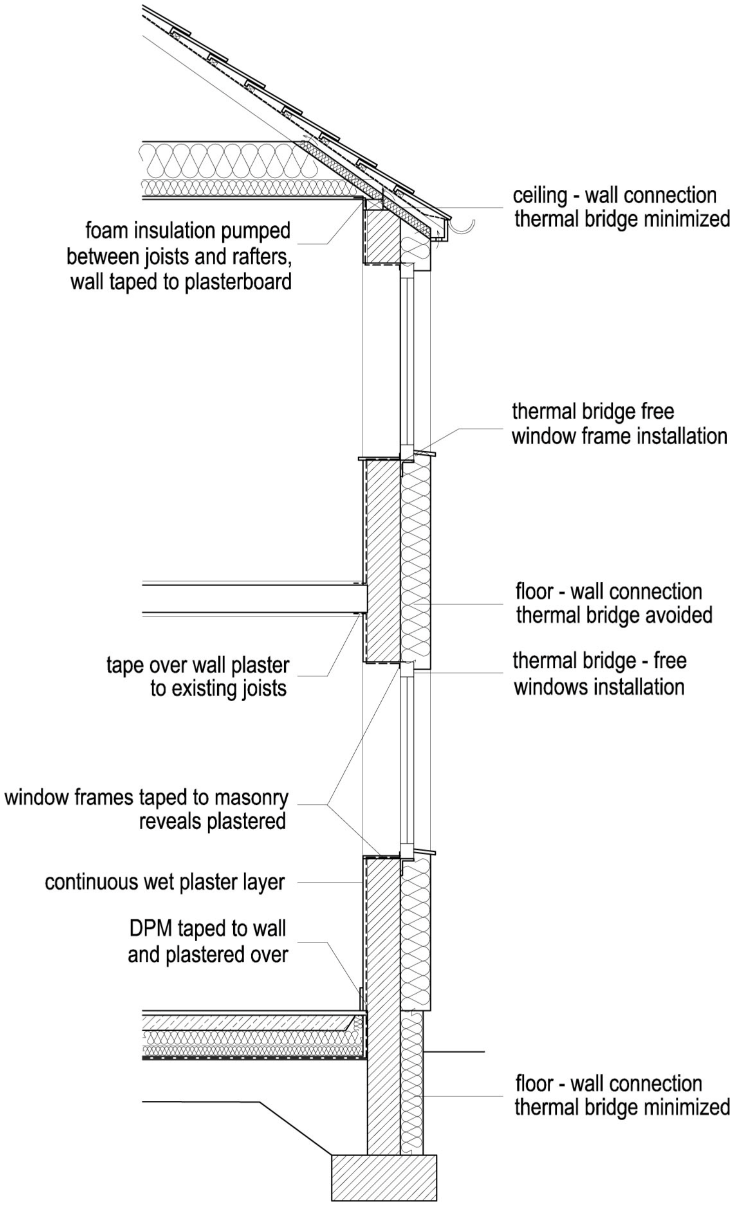

Figure 2. Section through externally insulated external wall

Installation of external insulation enhances the air tightness of the building, but additional measures are required to achieve the highest levels. This can be achieved by either installing sealed membranes and plasterboard, or internally plastering all external walls (or repairing existing plaster). The latter is easier and preferable for retaining the high thermal mass of the construction (discussion on thermal mass effects is provided in Appendix G). It is necessary to pay attention to careful application of a continuous layer of plaster. Difficult places include area between the joists in the depth of intermediate floor or narrow gap between the last joists along the wall. Where the plaster cannot be installed, open cell foam insulation can be applied or the joists can be taped to the wall.

The main benefit of external insulation is a possibility of elimination of most of the thermal bridging (there could be problematic areas in connections of walls with roofs due to the geometry of the existing building), because the insulation layer is continuous (Fig.8.). More importantly, the problem with water vapour condensing does not exist, as the walls are kept on the warm side.

One main disadvantage of external insulation is its cost. However, it can be mitigated if there is a need for a remedial work on external elevation anyway (for example to prevent rainwater penetration, or if the windows are being replaced or relocated). Its application both improves the dwelling’s appearance and extends its lifespan.

c. Calculations

Table 1 shows a comparison of four example installations. The performance and cost per square meter of each level takes into account the influence of thermal bridges associated with each application.

Option A is an internal insulation with 80mm of woodfibre insulation, breathable membrane and a 25mm service cavity filled with cellulose insulation, finished with plasterboard. A thicker insulation would take up too much space and the cavity zone ensures correct installation of vapour membrane. Options B to D include different thicknesses of grey polystyrene external insulation.

		(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€
	Baseline - no insulation	2.40	394				
A	80mm woodfibre + 20mm callulose in service cavity	0.34	248	146	€11,551.94	€132.78	1.10
B	150mm grey polystyrene external insulation	0.19	234	160	€12,414.90	€142.70	1.12
C	200mm grey polystyrene external insulation	0.15	230	164	€13,641.07	€156.79	1.05
D	300mm grey polystyrene external insulation	0.10	227	167	€15,786.85	€181.46	0.92

Table 1. Wall refurbishment options.