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The Hat Method – a Concept for Renovation towards the Passive House Standard

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SUMMARY:
Renovation towards the passive house standard is a challenge demanding a new way of insulating. Thermal bridges are efficiently eliminated and moisture problems are avoided. This implies the insulation work should be made in connection with facade and roof renovation. Insulation under the ground is often impossible but the hat method creates a coherent insulation layer from the roof to the façade and from the facade to the frost protecting insulation around the building. Consequently the area beneath the building will be kept warm and transmission losses decrease through a poorly insulated ground.
Fixations, spot footings and the like should be placed parallel to the isotherms reducing the thermal bridge effect to zero.
Constructions and building systems for roof, facade and the surrounding part of the ground can be done easily and rationally achieving the passive house standard.

1 Introduction

Retrofit insulation of buildings is often limited to insulation of cavities or semi accessible spaces such as the attic space and crawl space. The energy performance of insulated old buildings is inferior to the passive house standard due to the thermal bridge effect of all the construction assemblies and the limitations of the cavities. Internal insulation is possible to some extent but the thermal bridges are often impossible to eliminate. Additionally many internal insulation solutions have been questioned due to increased condensation and mould risk in non-visible building parts.

The post World War Two building stock, in particularly dwellings built during 1965 and 1975, are in need of radical renovation due to wear and tear. Swedish dwellings from the period 1965-1975 are commonly called The Million Program, referring to the number of dwellings needed to eliminate the housing shortage of that time. The Million Program comprises all sorts of dwellings such as multi-family houses, row houses and villas. [Miljonprogrammet 2008].

Most of the building stock from this time period is standardized basic rectangular buildings with very few architectural refinements and variations. It looks the same all over the country. Some apartment block areas have or have had severe social problems creating bad reputation affecting all housing areas of the type. When moving to a new town such housing areas are not the first choice.

Tenants and dwelling owners today have high expectations for energy performance, thermal comfort, quiet living and a healthy indoor environment. Accessibility for disabled or elderly people as well as pleasant and safe surroundings including a more town like environment with good public transportation is of high priority. These housing areas don’t match these expectations. On the contrary

these housing areas are spacious having favorable opportunities to be developed into perfect and attractive town quarters.

The process of developing the housing areas is a long and complicated task, but at some point in the process renovation, reconstruction and extension of the original buildings come into focus. Having identified the needs, physical possibilities and economic feasibility the construction process should be short with as little inconvenience and interruptions of the daily life of the inhabitants as possible.

2 The hat method

The hat method simply means that the old house and the surrounding ground are completely insulated; the building is covered with a wide brim hat.

The method is also an easy way of planning and reconstructing buildings to achieve the passive house standard. The method easily combines the need for renovation, reconstruction and extension in one process implying virtually just external construction work.

In this paper renovation of buildings with concrete ground slab is in focus, but buildings with basements or crawl space could also be renovated using a modified hat method.

Renovation towards the passive house standard is based on a different philosophy than traditional insulation. It is necessary to create a thick and coherent insulation layer from building part to building part. The insulation layer shall connect to the insulation of the ground to ensure high energy performance thus the area under ground will be kept warm. Deep under the building the temperature is constant at 6-10 °C in the southern part of Sweden and 2-5 °C in the northern part of Sweden. [Rosén 2001].

Keeping the ground warm the heat transmission is minimized due to the reduction of the temperature difference.

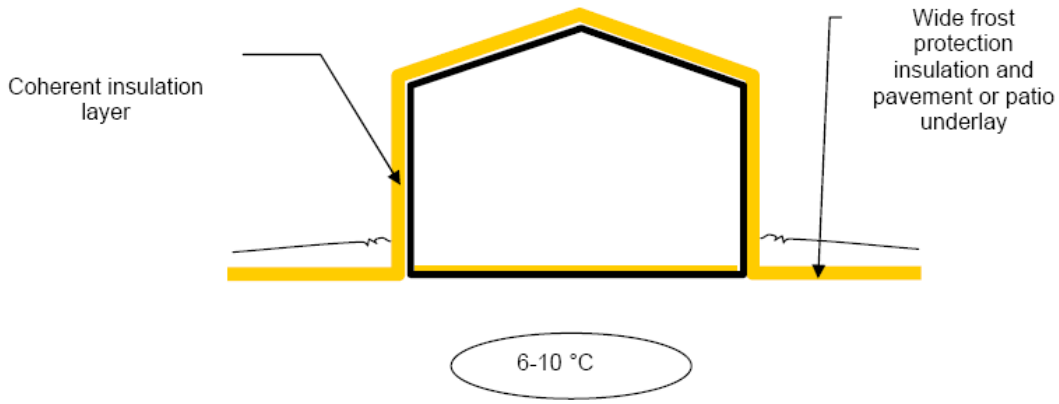

Figure 1 Passive house renovation principle – the hat method
A coherent insulation layer from the frost protection layer to the facade and roof with no thermal bridges. The insulation forms a wide brim hat. The ground beneath the house is kept warm reducing the heath transfer through a poorly insulated ground slab.

2.1 Advantages of the hat method

The advantages of the hat method are many:

- external insulation is often the only possibility to eliminate thermal bridges efficiently and to secure low heat loss as well as high thermal comfort
- the method minimises the risk of moisture related problems in the original building structure since the external insulation will protect it – the old structure will now be placed in the warm and dry part of the building envelope. This is very important!
- the method allows extension of the house in one construction process. Any extension – stair and lift well, balconies or glazed balconies/atriums, extended living space etc. is easily integrated in a complete house design.
- the method is simple since all the work is done externally allowing rational construction methods
- the living area is not reduced
- the house interior will only be slightly affected in cases where no particular interior renovation is needed.
- the inhabitants – tenants or owners – will often be able to live in the house during the construction period
- electrical installations and other installations are not affected. Possible electrical heating installation can be converted to additional outlets for household equipment.
- concerning buildings with unheated attic space:
    - ventilation ducts can be placed in the attic space. This is no longer cold but semi-conditioned since the additional insulation is placed above the roof boarding. The heat loss from insulated ventilation ducts placed in the heated attics will be acceptable.
    - the attic space will be a much better seasonal storage area
    - good opportunities for future change or extend electrical, communications cables or water pipes. It is also possible to change position of light sockets without being obliged to have visible cords and fixtures in the living room ceiling.
- Possible later internal renovation of the electrical installation in the walls and ceilings can be done neglecting the old vapour barrier in case the new vapour retarder is placed externally on the original structure to create air tightness. If at least 2/3 of the insulation is located to the external side and no more than 1/3 of the insulation to the internal side, the new vapour retarder takes over the complete function.

2.2 Choose the right opportunity for renovation

Renovation towards the passive house standard using the hat method is intended for houses with façade cladding and roof covering having non-structural function. Buildings with non-structural brickwork façade can preferably be renovated according to the hat method, too. A brickwork façade of solid bricks could be taken down carefully brick by brick and reused in a new façade. Concrete sandwich and block work facades are also possible to renovate using the hat method.

The renovation comes primarily into question when the building needs overall external restoration and upgrading such as new roof covering, windows and façade as well as surrounding facilities such as pavements and patios.

In cases where the façade is in good condition but the building is in need of extension to provide the desired facilities the extension might intrude on the façade. The intrusion might be to such a degree that a new façade would be a better solution from both a technical and architectural point of view.

2.3 Fixations

Traditional construction solutions penetrate the insulation layer to fix the cladding to the structure or penetrate the insulation to transfer the structure load from one building part to the next or to the ground. These penetrations are often considerable thermal bridges that conflict with the passive house energy performance level.

Only few penetrations are necessary when renovating using the hat method. In most cases it is possible to place fixations, spot footings and the like parallel to the isotherms reducing the thermal bridge effect to zero.

In particular, the facade can be made as a self-supporting exterior wall fixed to the roof construction at the top and supported by spot footings placed in the insulation layer along the isotherm corresponding to the ground temperature.

2.4 Isotherms

In southern Sweden the area just below the ground slab would be about 15 °C depending on how well or poorly it is insulated. The isotherms of a house renovated using the hat method is illustrated fundamentally in figure 2 for average outdoor winter temperatures of 0 °C in costal areas of southern Sweden. [SMHI 2009]

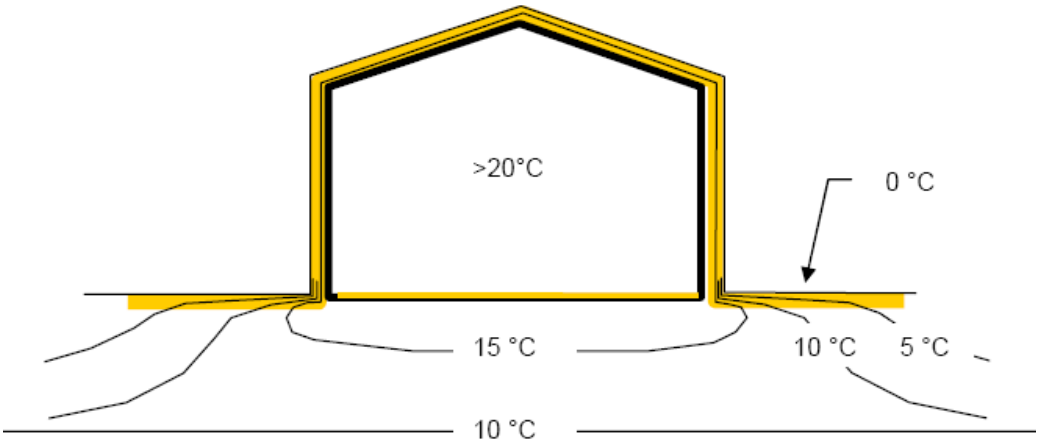

Figure 2 The isotherms of a hat method renovated house
The isotherms of the ground under poorly insulated concrete ground slab for average outdoor temperature during February in southern Sweden costal areas.

2.5 Thermal protection insulation width and thickness

The thickness and width of the thermal protection insulation should be calculated for specific cases knowing, in detail, the construction geometry, material and type of soil around the house foundation. A maximum temperature variation of a few degrees Celsius year round just under the foundation would be a reasonable assumption.

Although a precise calculation requires a lot of specific information, the width and thickness of the thermal protection insulation around the building can easily be estimated. Soil of clay and sand has a frost penetration depth of 1.2 m in costal areas of southern Sweden and 4 meters in northern Sweden inland areas. [Rosén 2001].
Usually the temperature varies very little below the double frost penetration depth due to the thermal mass and conductivity of the soil.

A corresponding thermal stability can be created around and under the house by using the hat method.

The conductivity of soil is about 1-2 W/mK. Suitable frost protection insulation of the XPS type polystyrene has a thermal conductivity of 0.034-0.370 W/mK which is 30-60 times lower than the conductivity of the soil. About 100 mm insulation would provide the same thermal protection of the area around the house in southern Sweden as soil having a thickness of the double frost penetration.

In general the thermal protection around the house corresponds to the double thickness of the normal frost protection thickness. The width should also correspond to the double frost penetration depth of the specific location to prevent the cold from reaching the house horizontally.

This width also happens to be about twice the minimum width of normal frost protection around building corners. In case large areas around the building are paved the insulation should form the underlay of the paved area to benefit from the simple and low depth pavement construction. [DOW 2006].

The approximate width and thickness for thermal protection insulation around a renovated house using the hat method is given in table 1.

Table 1 Approximate width and thickness for thermal protection insulation around a renovated house using the hat method

Location	Width, m	Thickness, mm
Malmö/Gothenburg	2.4	100
Stockholm	2.8	100
Gävle	3.2	140
Falun	4.0	200
Umeå	6.0	300
Kiruna	8.0	360

2.6 Self-supporting façades

In figure 3 isothermal position of a spot footing is shown. The spot footing shown would only carry vertical load, but the wind force also requires some horizontal fixation to keep the façade in position. This could be done using fixations having low heat conducting properties. Most fixations or ties pass straight through the insulation layer, but by angling the fixations at 45 degrees in the horizontal or vertical plane the heat transmission will be reduced by 30% due to the fact that the ties are longer. Additionally angled ties or fixations of the type shown in figure 5 are stronger than straight ties due to their triangle shaped structure.

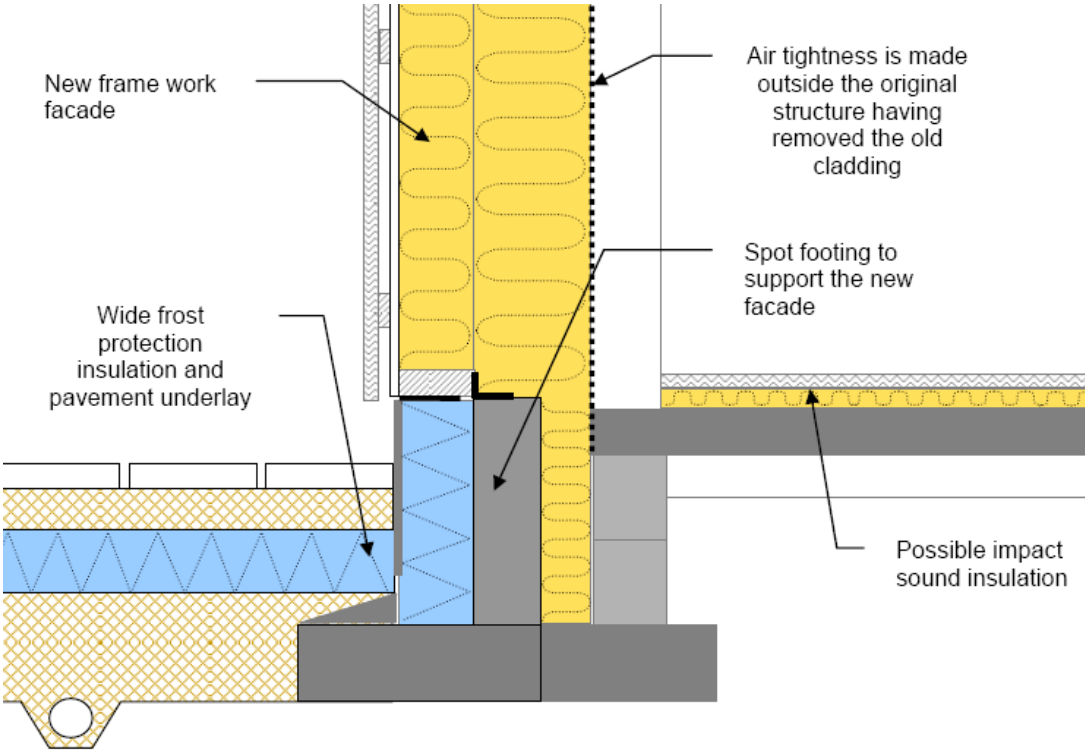

Figure 3 Spot footing
Spot footing positioned in the isotherm of the pad foundation which is about 15 °C. The spot footing could be made of reinforced concrete or steal without significantly increasing the thermal loss.

Non-structural brickwork facades are common in many post World War Two buildings in Sweden. It would probably be desired to give the renovated building the character of the old façade to some extent. In figure 4 a self- supporting brickwork façade is shown. The load of the brickwork requires a complete foundation. This foundation should be made of low conducting material such as lightweight concrete.

Invisible strengthening made as increased thickness of the brickwork is shown as dotted lines in the cavity.

The strengthening could also be made visible to express the structure of the self-supporting structure. Visible strengthening open up for a variety of façade designs as well as trimming of the wall thickness.

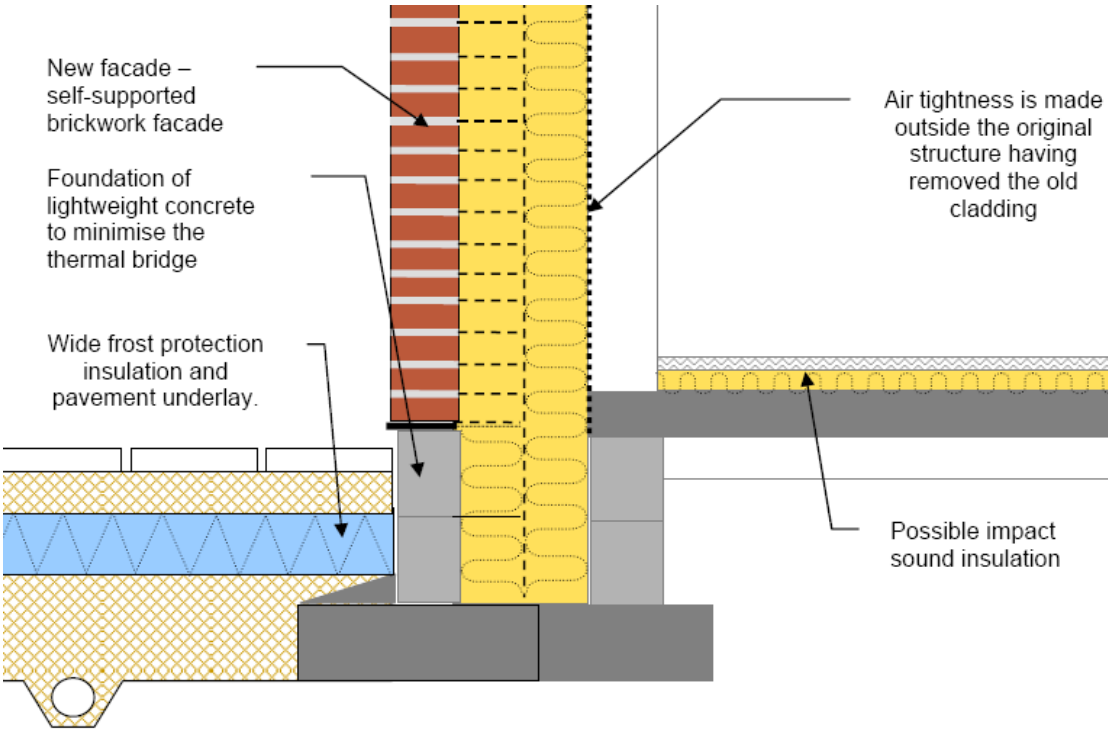

Figure 4 Self-supporting brickwork façade

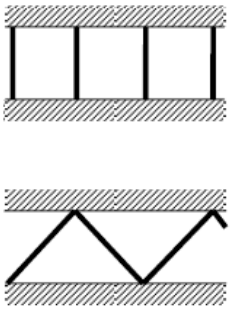

Figure 5 Ties
Ties passing straight through the insulation layer form larger thermal bridges than angled ties

2.7 Curtain facades

Light weight façades could preferably hang from the roof instead of standing on footings or foundations of its own. Old houses have structures that often are capable of bearing the load of the new façade as well as the extended roof.

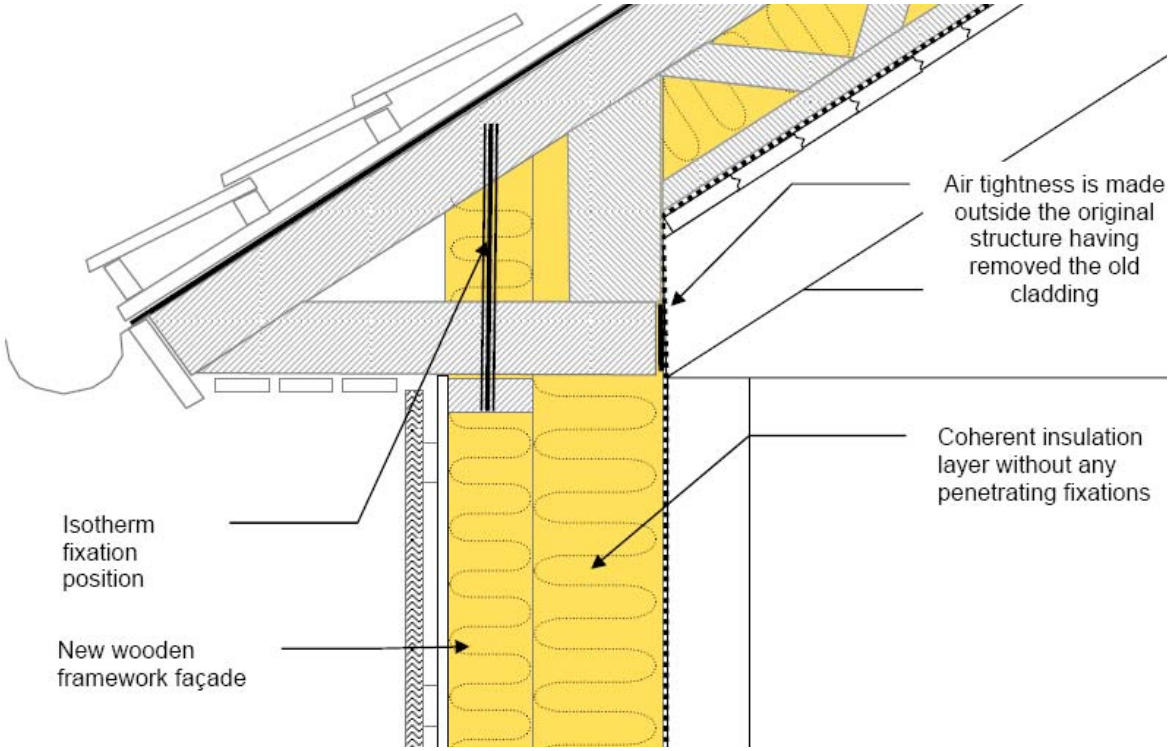

Figure 6 Curtain façade, roof - façade detail
Fixation positioned parallel to the isotherm. The extended roof is made as a "saddle" on the existing roof truss and boarding. In case sheeting material is desired for roof covering an additional roof boarding is needed as well.

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